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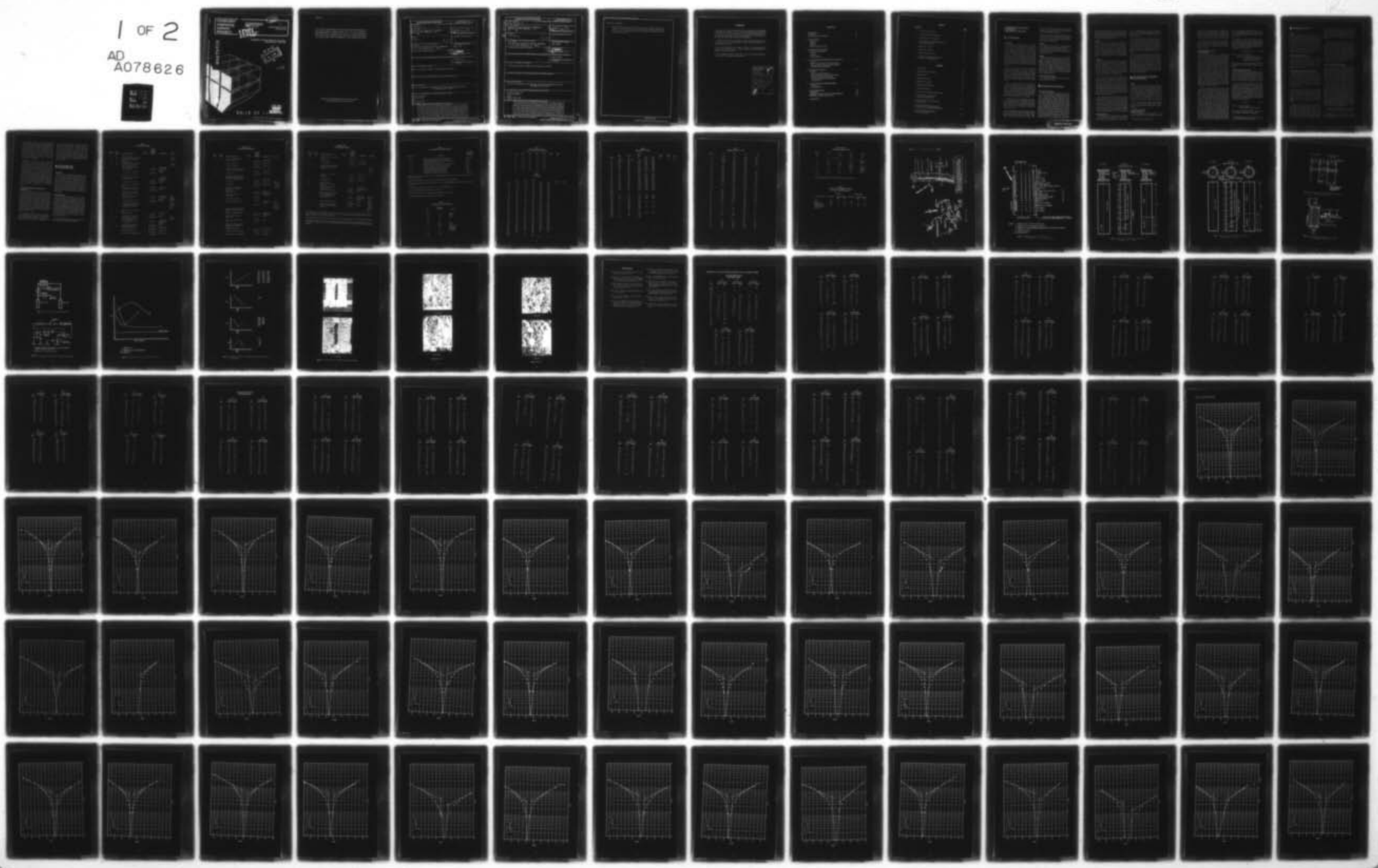

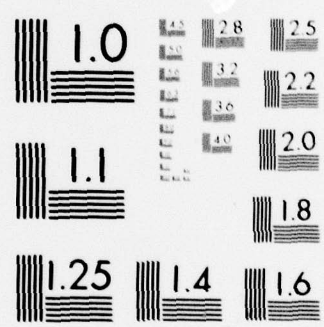

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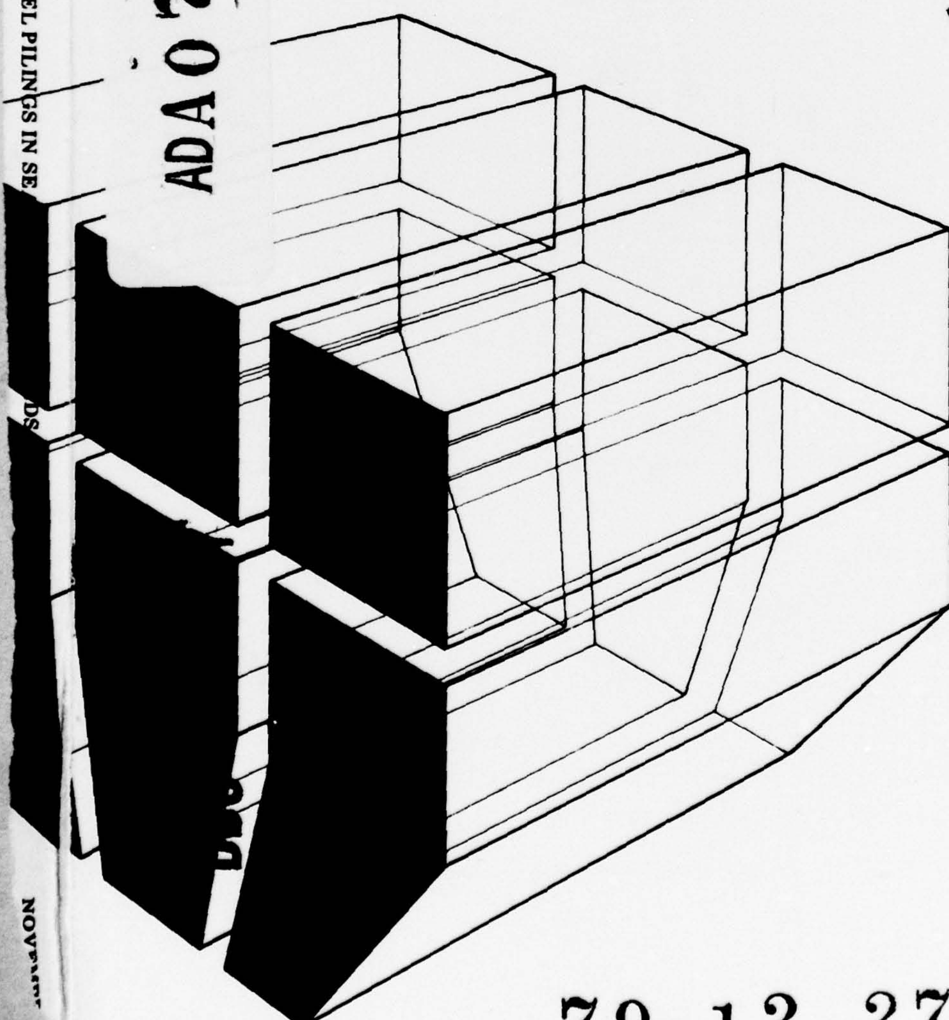
INTERIM REPORT M-275
November 1979

LEVEL II

CORROSION OF STEEL PILINGS IN SEAWATER: BUZZARDS BAY—1975-1978

by
F. Kearney



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To determine the effect of geography and temperature on corrosion of pilings that support various types of structures in coastal areas, a 5-year study is being conducted at Dam Neck, VA, LaCosta Island, FL, and Buzzards Bay, MA. This report (1) summarizes the results of annual inspections between 1975 and 1978 of the pilings at Buzzards Bay, (2) compares these results with the results of the Dam Neck and LaCosta inspections, and (3) provides electrochemical field test data that will be useful to researchers concerned with coastal structural design. The electrical measurements of corrosion at Buzzards Bay were found to differ drastically from LaCosta and Dam Neck results.

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To determine the effect of geography and temperature on corrosion of pilings that support various types of structures in coastal areas, a 5-year study is being conducted at Dam Neck, VA, LaCosta Island, FL, and Buzzards Bay, MA. This report (1) summarizes the results of annual inspections between 1975 and 1978 of the pilings at Buzzards Bay, (2) compares these results with the results of the Dam Neck and LaCosta inspections, and (3) provides electrochemical field test data that will be useful to researchers concerned with coastal structural design. The electrical measurements of corrosion at Buzzards Bay were found to differ drastically from LaCosta and Dam Neck results. cont'

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These differences were attributed to site-specific factors, and have tentatively been attributed to the high degree of marine life fouling noted on pilings at the Buzzards Bay test sites. It is recommended that further inspections include examinations of the pilings by marine biologists.

FOREWORD

The inspection of pilings at Buzzards Bay, MA, was conducted by the Engineering and Materials Division (EM), U.S. Army Construction Engineering Laboratory (CERL) for the Directorate of Civil Works, Office of the Chief of Engineers (OCE). The work was performed under CWIS 31204, "Corrosion Mitigation in Civil Works Projects." Mr. J. Robertson, DAEN-CWE-E, is the OCE Technical Monitor.

The CERL inspection team included Mr. F. Kearney (electrical measurements and data analysis), Dr. A. Kumar (visual inspection), and Mr. F. Kisters (planning and coordination of field operations).

Appreciation is expressed to Mr. C. Hahin of CERL for his work during the initial phase of the CERL piling studies, and to Mr. E. Escalante of the National Bureau of Standards for his helpful comments.

Dr. G. R. Williamson is Chief of EM. COL L. J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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CORROSION OF STEEL PILINGS IN SEAWATER: BUZZARDS BAY—1975-1978

1 INTRODUCTION

Background

The Directorate of Civil Works, Office of the Chief of Engineers (OCE), has jurisdiction over many coastal area structures which are supported on pilings (e.g., harbors, bridges, and buildings). In the past, steel pipe and H-pilings have generally been used for foundations in coastal areas; however, more recently, prestressed concrete pilings have also been used. Because there is a lack of quantitative data on the rate of piling corrosion and the performance of coatings and sacrificial anodes on steel pilings under long-term field exposures, designers of such structures are faced with the problem of not knowing how quickly they corrode.

In 1965, OCE directed the Coastal Engineering Research Center (CERC) to study the corrosion of steel pilings in seawater. Concurrently, the National Bureau of Standards (NBS) was planning a seawater piling corrosion study with funds provided by the American Iron and Steel Institute. To prevent duplication of effort, NBS and CERC made the study a joint effort.

A test site near Dam Neck, VA, was selected, and 102 pilings were installed in June 1967. Annual inspections of the piles were conducted, and inspection reports were prepared by NBS and distributed to participating offices within the Corps. The 102 pilings were grouped into 31 sets (three identical pilings per set); every 5 years, one piling from each set was to be extracted and examined for corrosion damage.

To determine the effect of geography and temperature on piling corrosion, CERC selected two more sites (LaCosta Island, FL, and Buzzards Bay, MA). Piling installation at LaCosta Island was completed in January 1971, and the pilings have been inspected annually since then.

In 1973, the major Corps research for this study was transferred from CERC to the U.S. Army Construction Engineering Research Laboratory (CERL). CERL installed pilings at Buzzards Bay in October 1974. The first set of piles will be extracted in 1979, with the study to be completed in 1989, this will complete the Buzzards Bay phase of the study.

When the Dam Neck and LaCosta Island studies are completed, the data from all three sites will be analyzed in order to draw conclusions and develop recommendations about pile coatings.

Objective

The objective of this study was to summarize the results of CERL's annual inspections of the test pilings at Buzzards Bay from 1975 through 1978, and to compare these results with the results of the Dam Neck and LaCosta inspections.

Approach

Pilings were installed at the test site; some had no protective coating or sacrificial anode, while the remainder were given various types of protection. The pilings were inspected both visually and by electrochemical measurements annually from 1975 through 1978. The data obtained from these inspections were analyzed and evaluated. Differences were noted between data obtained from the Dam Neck and LaCosta sites, so tests were run to verify the reliability of the measurement system.

Mode of Technology Transfer

The information contained in this study will be incorporated into TM 5-811-4.

2 BUZZARDS BAY FIELD STUDY

Protective Coating Systems

A variety of coatings and sacrificial cathodic protection anodes was used in the Buzzards Bay study in order to correlate protection methods with the life cycles of pilings used at Corps of Engineers installations. Table 1 lists the coatings and their sources. Some pilings were installed without any coating or sacrificial anodes, while others were installed with both coatings and cathodic protection. Most of the protective coating systems included in the Buzzards Bay test site are the same type as those used at the Dam Neck and LaCosta Island sites. The systems include organic coatings, metallic coatings, and zinc-rich primers with topcoats. The organic coatings include coal tar epoxies, saran, vinyl, phenolic mastic, epoxy polyamide, epoxy over inorganic ceramic, and polyester over glass flake.

Metallic coatings include flame-sprayed aluminum and zinc with and without organic topcoats. The coatings were applied after sandblasting the base metal to "near white metal" according to Steel Structures Painting Council Specification SSPC-SP-10-63T.

Test Site

Figures 1 and 2 show the location of the Buzzards Bay test site. In comparison to Dam Neck and LaCosta, this site has a lower mean temperature; in addition, its hydrology differs because it is located in a protective, cove-like area similar to an estuary. Furthermore, the test pilings at this site are subjected to rather massive ice flows which cause severe mechanical loads. These ice conditions destroyed some of the pilings in 1977.

Test Pilings

The test pilings included both H and pipe pilings made of either American Society for Testing and Materials (ASTM) A 36 or ASTM 690 (mariner) steel. The steel H piles were 8 in. X 8 in. X 40 ft (203.2 mm X 203.2 mm X 12.19 m) and weighed 36 lb/ft (54 kg/m). Eight prestressed concrete pilings were also installed on the bay side of the steel pile array. Figure 3 illustrates the installation plan.

The steel pilings formed three rows designated as A, B, and C. Row A pilings were completely coated, Row C pilings were coated except for the lower 15 ft (4.57 m), and Row B pilings were coated except for rectangular areas covered by clear acrylic plastic windows. Stainless steel rods were welded between the inside flanges of each piling to enable electrical contact for obtaining electrochemical measurements. Figures 4 and 5 show details of the H and pipe piling coating details. Figure 6 shows an elevation view of Row 1, which is typical of all piling rows.

The sacrificial anodes for the cathodically protected piles were mounted near the sand zone and consisted of either zinc or aluminum. The zinc anodes were 4 X 4 X 36. in. (101 X 101 X 914 mm) and weighed 150 lb (68.0 kg) when new; the aluminum anodes were 4 X 4 X 38 in. (101 X 101 X 967 mm) and weighed 60 lb (27.2 kg) when new. Two anodes were installed on each piling to provide cathodic protection; Figure 7 shows a detailed section of the anode mounting.

Annual Inspections

After placement, the pilings were inspected visually and by electrochemical measurements five times per year. Visual observations included a complete evaluation of coating deterioration and were conducted in accordance with ASTM standard methods for evaluating the degree of rusting of painted steel surfaces, D610-68 (Table 2).

Electrical measurements were taken for pile corrosion potential, cathodic protection index, and polarization. Electrical contact with the stainless steel rods in the piles was made by connecting vise clamps to the cable wires that were joined to instrumentation on the beach. The pile potential was measured on pilings provided with sacrificial anodes in order to indicate the degree of protection offered by the anodes.

Each 40-ft (12-m) length of piling was divided into five zones: the buried zone (0 to 15 ft [0 to 4.57 m]), the sand zone (15 to 17 ft [4.57 to 5.18 m]), the immersion zone (17 to 27 ft [5.18 to 8.23 m]), the tidal zone (27 to 31 ft [8.23 to 9.45 m]), and the atmospheric zone (31 to 40 ft [9.45 to 12.15 m]). Only pilings in the tidal and atmospheric zones could be visually inspected because they were not under water. These zones were inspected and evaluated in accordance with D610-68. Table 3 gives the results of the 1978 visual inspections.

3 ELECTROCHEMICAL CORROSION FIELD TEST DATA

General

The most insidious aspect of the corrosion of submerged and buried structures is the inspector's inability to determine the level or rate of deterioration caused by the corrosion process. Coupled with this problem is the equally difficult task of monitoring the effectiveness of corrosion abatement procedures. In recent years, laboratory electrochemical corrosion-rate measurements have been adapted for in-situ field measurements, but have not been very successful.

This study incorporates three electrochemical experiments to evaluate the feasibility of such measurements as a reliable in-situ, nondestructive evaluation technique.

Sacrificial Anode Cathodic Protection Performance

Of the 24 piling systems, three (systems 2, 5, and 6)* were installed with zinc sacrificial (galvanic) anodes

*Refer to Figure 3 for designation legend.

(see Figure 7), while system 3 was installed with aluminum anodes. The potentials of these protected pilings were measured with respect to a copper/copper sulfate reference electrode. Table 4 gives the results of the potential measurements for 1975 through 1978.

As the pilings were pulled at each 5-year interval, their anodes were cleaned of marine life, weighed, and their consumption rate computed; these data will be presented in the 5-year exposure reports to be published in FY 1980.

Polarization Measurements and Tafel Extrapolations

In the corrosion process, the corroding metal dissolves into the electrolyte solution, which develops a current flow within the metal called the corrosion current. In this electrochemical reaction, positive ions, such as iron, are released into the electrolyte solution, and positive ions, such as hydrogen, are produced. This process develops an exchange current at the surface of the corroding metal; this exchange current is directly related to the corrosion rate, or loss, of metal with time. Because this exchange current is molecular in nature, it cannot be measured directly; however, an indirect measuring technique is possible (see Figure 8). To measure the current indirectly, the voltage applied to the test piling is varied and the current is monitored by the amp meter while the "electrochemical" potential is measured by a reference cell. This reference cell potential is measured by a high-impedance metering circuit. Figure 9 is a schematic of the actual circuit used for these tests.

The curve of voltage vs. the log of current is called a polarization curve; Appendix A provides the polarization curves obtained in 1977 and 1978. Two polarization curves are shown for each piling. The lower curve is the cathodic protection curve obtained when the test piling is negatively charged, while the upper curve is obtained when the test piling is positively charged, or anodic. For low currents, the curve is nonlinear, but at higher currents it becomes linear on the semilogarithmic plot; this region of linearity is called the Tafel region. To determine the corrosion rate from these polarization measurements, the Tafel region is extrapolated to the corrosion potential, as shown by the downward sloping tangent lines on the polarization plots. At the corrosion potential, the rate of hydrogen evolution is equal to the rate of metal dissolution, and this point corresponds to the corrosion rate of a particular piling system being tested. Inherent in this technique is the current density factor; hence, the area of the piling submerged enters into the corrosion rate determination. Thus, it is necessary to know the water depth variation with tide at the time of the measurement.

The cathodic corrosion current (indicated as I_q on these polarization plots) is used for most corrosion current measurements. Schwerdtfeger and McDorman[1] described a "polarization break" method which uses breaks in the anodic and cathodic polarization curves to calculate a corrosion current, I_C:

$$I_C = (I_p)(I_q)/(I_p + I_q) \qquad \text{[Eq 1]}$$

where: I_C = the corrosion current
I_p and I_q = the tangent intersections of the linear portions of the anodic and cathodic curves, respectively.

Tables 5 and 6 provide the values extracted from the polarization curves and the Schwerdtfeger corrosion current.

Cathodic Protection Index Results

Most coatings applied to metal structures can be characterized as a film exhibiting high electrical resistance, i.e., an insulating layer. Studies have shown a correlation between coating effectiveness and the film's electrical resistance; this provides an in-situ means of measuring the performance of coatings.

In practice, the same measurement setup shown in Figures 8 and 9 is used to perform these coating effectiveness measurements. For the CERL piling corrosion studies, this is called the cathodic protection index. To perform the measurement, the potential, as measured by the half-cell, is changed from the open circuit potential to −0.850 volts vs. copper/copper sulfate, and the current required to effect this change is measured. The cathodic protection index (CPI) is then the ratio of these values:

$$\mathrm{CPI} = \frac{V}{I} \qquad \text{[Eq 2]}$$

where: V = change in voltage
I = current required to shift the voltage

These values are tabulated in Table 7 for the years 1975 through 1978 and plotted in Appendix B.

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[1] W. J. Schwerdtfeger and O. N. McDorman, *Journal of the Electrochemical Society*, Vol 99 (1952), p 407.

4 DISCUSSION OF RESULTS

General

After completion of the field tests, the data obtained were analyzed and evaluated; after the third year of exposure, it became apparent that there were differences in the trend of the cathodic protection indices relative to the data obtained from the Dam Neck and LaCosta sites. To insure that these differences were not caused by instrumentation errors, several tests were run to verify the reliability and accuracy of the test measurements system. After the instrumentation reliability had been verified, other reasons for these differences were examined.

Cathodic Protection Performance

As indicated in Table 4, the pilings with sacrificial anode cathodic protection exhibited a protection potential well above the 0.850-V (reference: copper/copper sulfate) level. The only uncompleted portion of this part of the study is the determination of the consumption rate; this will be completed when the pilings are extracted in 1979.

Corrosion Rates From Polarization Measurements

Although an absolute value of corrosion current for steel in salt water cannot be defined because of modifying factors such as water velocity, etc., a range of 5 to 15 mA/sq ft (50 to 150 mA/m^2) is reasonable. A good quality coating system will reduce this figure to 5 to 15 A/sq ft (50 to 150 A/m^2). As mentioned previously, the coating system serves to insulate the metal from the electrolyte, thereby eliminating the current/ion flow path.

Inspection of the polarization curves in Appendix A and the tabulated break-point values given in Tables 5 and 6 reveals that the measured corrosion currents are very low. This data by itself would indicate a good coating system; however, this conclusion is not valid because low values for corrosion current are also obtained for the bare steel pilings—specifically systems 1 and 4.

To illustrate this, Table 8 compares two bare steel pile systems—one from the LaCosta study and one from the Buzzards Bay study for the years 1977 and 1978. The table also includes data for both sites from two similar coal-tar-epoxy-coated systems. The LaCosta bare steel average corrosion current density was 2.92 mA/sq ft (29.2 mA/m^2), which is not an unreasonable value, while the comparable Buzzards Bay piling was 1 mA/sq ft in 1977 and 0.73 mA/sq ft (7.3 mA/m^2) in 1978. Similarly, the coal-tar-epoxy system at LaCosta had a corrosion current density of 0.93 mA/sq ft (9.3 mA/m^2), while the comparable piling coating at Buzzards Bay was .49 mA/sq ft (4.9 mA/m^2) in 1977 and .52 mA/sq ft (5.2 mA/m^2) in 1978.

To verify the instrumentation and the various electrical connections, a test plate of new carbon steel was placed approximately 20 ft (6 m) from the auxiliary pile (row 22C), and a polarization curve was run on the new test steel plate; a graph in Appendix A (p 130) shows this polarization curve. The Tafel extrapolation gives an I_q of 300 mA; this value, divided by the area of the plate, gives a corrosion current density of 9.375 mA/sq ft (93.75 mA/m^2). This test verified the validity of the test data obtained by means of this measuring system and confirmed the existence of a high-resistance coating on the pilings.

Analysis of Cathodic Protection Indices

A review of literature that discusses the use of a Cathodic Protection Index to evaluate coatings on pilings in seawater indicates that CPI versus time curves can be grouped into three characteristic shapes (see Figure 10). Group I would represent nonmetallic coatings exhibiting a progressive deterioration of the coating and resultant reduction in surface film resistance, as shown by a decreasing CPI. Group II would typify a nonmetallic coating over a metallic primer such as zinc-rich primer. This curve shows a decreasing CPI caused by deterioration of the finish coat until the film thickness is reduced to the point where the sacrificial protection of the metallic primer becomes operative. Group III would represent the family of metallic coatings, such as flame-sprayed aluminum; in this instance, the CPI would increase with the information of corrosion products on the metallic coating (which would provide additional protection), then would reach an apex before beginning a gradual decrease that would indicate the failure of the metallic coating and subsequent increased corrosion of the base steel. Escalante gives an excellent summary of specific electrochemical data, showing these characteristic curves for the test pilings at Dam Neck.[2]

To analyze the Buzzards Bay data, the CPI data were grouped as shown in Figure 11. Accompanying

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[2] E. Escalante, et al., *Protection of Steel Piles in a Natural Seawater Environment—Part II*, NBSIR 76-1104 (National Bureau of Standards, 1976).

each characteristic curve is a list of specific pilings that exhibited this CPI variation. This grouping differs from data obtained at LaCosta and Dam Neck in two major ways: (1) only one piling system falls into the conventional deterioration pattern 10b-20a, and (2) the bare pile systems (1, 4, and 22) exhibit an increasing CPI rather than a constant level of corrosion rate. The latter variation is of greatest concern, and prompted the continuous verification of instrumentation equipment and methods.

Because the information obtained from CPI measurements is the surface coating resistance, the only conclusion that can be drawn from the curves for pilings having an increasing CPI is that some mechanism is interacting with the surface and causing a high-resistance coating to form. The distribution of the other pilings (see Figure 10) indicates that this mechanism is neither consistent nor uniform. A microcomputer program used a corrective algorithm to transform the data to a synthetic bare-piling baseline displaying trivial results; with some statistical manipulations, the same results were obtained. An evaluation of the environmental conditions at this test site was more encouraging, as explained in the following section.

Interrelationship Between Coastal Structures and Marine Life

It has frequently been observed that clusters of marine life or metal structures in seawater can provide an insulation barrier between the metal and surrounding electrolyte similar to a protective coating. The electrical resistance of marine life colonies has been illustrated by instances of cathodic protection systems which have been rendered inoperative by the formation of such clusters on the anodes. It was therefore hypothesized that the increasing CPI values noted at the Buzzards Bay sites could have been caused by marine life fouling; however, the cause of the irregular pattern remained a puzzle.

An examination of the life cycle of marine life in this geographical location enhanced the probability of this possibility. Figure 12 shows a 5-year life cycle of marine life growth, followed by a "sloughing off" of the growth and a reexposure of the metal, which exhibited a different surface condition. Figure 12 shows only a small section of the exposed steel; however, several colonies of marine life distributed over the approximately 40 sq ft (3.6 m^2) of a submerged test piling would have different life cycles and densities, resulting in a complex variation of net electrical coating resistance. The growth of *filamentus bryozoa*, a species endemic to Buzzards Bay, is very evident in Figure 12.

5 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The electrical measurements (polarization and cathodic protection index) obtained in this series of tests at Buzzards Bay differ drastically from the LaCosta and Dam Neck test results. Since the test equipment and procedures were identical at each location, the variation must have been caused by site-specific factors. A tentative conclusion reached after this research is that growth on the test pilings of marine life endemic to the estuary conditions at Buzzards Bay is the principal cause of the anomalous data pattern.

Recommendations

Because electrical measurements are potentially powerful techniques for the nondestructive evaluation of coating performance on submerged structures, the remainder of the piling studies should be modified in order to rigorously evaluate the marine life fouling hypothesis. Specifically, all retrieved pilings should be examined immediately after extraction by a marine biologist familiar with the marine life species indigenous to Buzzards Bay. Each annual inspection should include an assessment of the growth pattern in order to establish correlation of growth with the change in electrical parameters.

Annual cathodic protection measurements and the plotting of polarization should be continued.

Table 1
Test Pile Preparation Details

System No.	Type of Pile*	Type Pile and Protection	No. of Coats	Total Dry Coating Thickness (mils)**	Coating Source†	Remarks
1	H	Bare Carbon Steel	—	—	—	—
2	H	Bare Carbon Steel with Zinc Anodes	—	—	—	2 Anodes
3	H	Bare Carbon Steel with Aluminum Anodes	—	—	—	2 Anodes
4	H	Bare Mariner Steel	—	—	—	—
5	H	Bare Mariner Steel with Zinc Anodes	—	—	—	2 Anodes
6	H	Coal Tar Epoxy, over Zinc-Rich Primer, with Zinc Anodes	—	—	—	2 Anodes
		- Epoxy Zinc-Rich Primer CERL Formula No. E-303	1	2.5 (0.06 mm)	Iowa Paint Mfg. Co. (Via CERL Paint Lab)	
		- Formula C-200, Coal Tar Epoxy	2	16-20 (0.41-0.51 mm)	Koppers	
7	H	Coal Tar Epoxy, over Zinc-Rich Primer				
		- Epoxy Zinc-Rich Primer CERL Formula No. E-303	1	2.5 (0.06 mm)	Iowa Paint Mfg. Co. (Via CERL Paint Lab)	
		- Formula C-200, Coal Tar Epoxy	2	16-20 (0.41-0.51 mm)	Koppers	
8	H	Coal Tar Epoxy, over Zinc-Rich Primer				
		- Porter Zinc-Lok No. 352 Primer	1	1 (0.03 mm)	Porter Paint Co.	
		- Formula C-200, Coal Tar Epoxy	2	16-20 (0.41-0.51 mm)	Koppers	
9	H	Coal Tar Epoxy, over Zinc-Rich Primer, Aluminum Oxide Armored at Mud Line				
		- Epoxy Zinc-Rich Primer NCR Formula No. E-303	1	2.5 (0.06 mm)	Iowa Paint Mfg. Co. Via CERL Paint Lab	4th coat + grit to be applied 17 ft and 23 ft (5.18 and 7.01 m) from bottom of pile
		- Formula C-200, Coal Tar Epoxy	2	16-20 (0.41-0.51 mm)	Koppers	
		- Formula C-200, Coal Tar Epoxy + Aluminum Oxide Grit (No. 30) Broadcast into Wet Final Coat				
10	H	Coal Tar Epoxy, over Epoxy Resin Primer				
		- Epoxy Resin Primer	1	3 (0.08 mm)	Porter Paint Co.	
		- Formula C-200, Coal Tar Epoxy	2	16-20 (0.41-0.51 mm)	Koppers	
11	H	Coal Tar Epoxy, over Zinc-Rich Primer, on Mariner Steel				Mariner steel pile
		- Epoxy Zinc-Rich Primer NCR Formula No. E-303	1	2.5 (0.06 mm)	Iowa Paint Mfg. Co. (Via CERL Paint Lab)	
		- Formula C-200, Coal Tar Epoxy	2	16-20 (0.41-0.51 mm)	Koppers	
12	H	Epoxy over Inorganic Ceramic				
		- Plas-Chem Zinc-ite Primer	1	3-4 (0.08-0.09 mm)	Plas Chem Corp.	
		- Plas-Chem Ceram-ite No. 101	1	5-6 (0.12-0.15 mm)	Plas Chem Corp.	
		- Plas-Chem 2140Z High Build Epoxy	1	7-8 (0.18-0.20 mm)	Plas Chem Corp.	

Table 1 (Cont.)
Test Pile Preparation Details

System No.	Type of Pile*	Type Pile and Protection	No. of Coats	Total Dry Coating Thickness (mils)**	Coating Source†	Remarks
13	H	Epoxy over Organic Zinc Primer				
		- Zincor No. 11 Primer	1	1-1.5 (0.03 mm-.04 mm)	Plas Chem Corp.	
		- Chem-Pon 2310X Red	1	8-9 (0.20-0.23 mm)	Plas Chem Corp.	
		- Chem-Pon 2310X Gray	1	8-9 (0.20-0.23 mm)	Plas Chem Corp.	
14	H	Polyurethane over Organic Zinc Rich				
		- Chemglaze Zinc-Rich Primer 9927	1	3 (0.08 mm)	Hughson Chem	
		- Chemglaze II	2	3-5 (0.08-0.12 mm)	Hughson Chem	
15	H	Polyurethane over Organic Zinc Rich with an intermediate Elastomer Coat				
		- Chemglaze Zinc-Rich Primer 9927	1	3 (0.08 mm)	Hughson Chem	
		- M312 Elastomer	1	6-8 (0.15-0.20 mm)	Hughson Chem	M312 is High Build -1 coat up to 10 mils (0.25 mm)
		- Chemglaze II	2	3-5 (0.08-0.12 mm)	Hughson Chem	
16	H	Polyurethane over Flame Sprayed Zinc, with Intermediate Wash-coat Primer				
		- Flame Sprayed Zinc	1	3-4 (0.08-0.09 mm)	Metalweld or Metco Urecal Co.	
		- Washcoat Primer Formula 117, MIL-P-15328	1	0.5 (0.12 mm)	Via Seaguard Co.	
		- Urecal 9301 Polyurethane	2	4 (0.09 mm)		
17	H	Aluminum, Flame Sprayed (Wire)	1	6 (0.15 mm)	Metalweld, Metco or equal	Steel Wire Flash Bonding Coat 1 mil (0.03 mm) Steel Wire
18	H	Aluminum, Flame Sprayed with Wash-coat Primer and Aluminum Vinyl Sealer				
		- Flame Sprayed Aluminum (Wire)	1	3-4 (0.08-0.09 mm)	Metalweld, Metco or equal Via Sea-guard Co.	
		- Washcoat Primer Formula 117, MIL-P-15328	1	0.5 (0.12 mm)		
		- Metcoseal AV, Aluminum Vinyl Sealer	2	2 (0.05 mm)	Metco	
19	H	Zinc, Flame Sprayed, with Coal Tar Emulsion over Coal Tar Solution Top coats				
		- Flame-Sprayed Zinc (Wire)	1	3-4 (0.08-0.09 mm)	Metalweld or Metco	
		- Wise Chem T-265 Coal Tar Solution	1	15 (0.38 mm)	Wise Chem Co.	
		- Wise Chem T-264 Coal Tar Emulsion	1	7-8	Wise Chem Co.	

Table 1 (Cont.)
Test Pile Preparation Details

System No.	Type of Pile*	Type Pile and Protection	No. of Coats	Total Dry Coating Thickness (mils)**	Coating Source†	Remarks
20	H	Vinyl Glass Flake, over Vinyl Zinc Rich		(0.18-0.20 mm)		
		- Vinyl Zinc Rich	1	2-3 (0.05-0.08 mm)	CERL Paint Lab	
		- Vinyl Glass Flake	3	6 (0.15 mm)	CERL Paint Lab	
21	H	Vinyl Mastic over Synthetic Resin Tiecoat over Washcoat Inorganic Zinc Primer				Curing solution to be removed by fresh water
		- Dimetcote No. 3 + D3 Curing Solution	1	3 (0.08 mm)	Amercoat Corp.	
		- No. 54 Tiecoat	1	1 (0.03 mm)	Amercoat Corp.	
		- Vinyl Mastic No. 87	1	10 (0.25 mm)	Amercoat Corp.	
22		Pipe Bare Carbon Steel	—	—	—	—
23		Pipe Coal Tar Epoxy over Zinc-Rich Primer				
		- Epoxy Zinc-Rich Primer NCR Formula No. E-303	1	2.5 (0.06 mm)	Iowa Paint Mfg. Co. (Via CERL Paint Lab)	
		- Formula C-200, Coal Tar Epoxy	2	16-20 (0.41-0.51 mm)	Koppers	
24		Pipe Coal Tar Epoxy, Armored at Mud Line, over Zinc-Rich Primer				
		- Epoxy Zinc-Rich Primer NCR Formula No. E-303	1	2.5 (0.06 mm)	Iowa Paint Mfg. Co. (Via CERL Paint Lab)	4th coat & al oxide to be applied between 17 & 23 ft (5.18 & 7.01 mm) from bottom of pile
		- Formula C-200, Coal Tar Epoxy	2	16-20 (0.41-0.51 mm)	Koppers	
		- Formula C-200 + Aluminum Oxide (No. 30 Grit) Broadcast into Wet Final Coat	1	10 (0.25 mm)	Koppers	

*Steel H-piles are 40 ft (12.19 m) lengths of 8 in. × 8 in. × 36 lb (20.32 cm × 20.32 cm × 16.33 kg) mild carbon steel, except systems 4, 5, and 11, which are "Mariner" steel H-piles. Systems 22, 23, and 24 are pipe piles, mild carbon steel, 8 in. (20.32 cm) diameter, schedule 40, 0.322 in. (0.82 cm) wall thickness.

**Film thickness tolerance per coat may be plus or minus 15 percent of given thickness per coat when no thickness range is given.

†An approximately equal brand name coating with application and preparation instructions can be furnished by the Government from the same or another source. CERL is symbol for the Paint Laboratory at the U.S. Army Construction Engineering Research Laboratory.

Table 2
Scale and Description of Rust Grades*

Rust Grades**	Description	SSPC-ASTM Photographic Standard
10	No rusting or less than 0.01 percent of surface rusted	unnecessary
9	Minute rusting, less than 0.03 percent of surface rusted	No. 9
8***	Few isolated rust spots, less than 0.1 percent of surface rusted	No. 8
7	Less than 0.3 percent of surface rusted	none
6†	Extensive rust spots but less than 1 percent of surface rusted	No. 6
5	Rusting to the extent of 3 percent of surface rusted	none
4††	Rusting to the extent of 10 percent of surface rusted	No. 4
3†††	Approximately one-sixth of the surface rusted	none
2	Approximately one-third of the surface rusted	none
1	Approximately one-half of the surface rusted	none
0+	Approximately 100 percent of the surface rusted	unnecessary

*Reprinted with permission of American Society for Testing and Materials from *Evaluating Degree of Rusting on Painted Steel Structures*, ASTM D 610-68.

**Similar to European Scale of Degree of Rusting for Anti-Corrosive Paints (1961) (black and white).

***Corresponds to SSPC Initial Surface Condition E (0 to 0.1 percent) and BISRA (British Iron and Steel Research Association) 0.1 percent.

†Corresponds to SSPC Initial Surface Condition F (0.1 to 1 percent) and BISRA 1.0 percent.

††Corresponds to SSPC Initial Surface Condition G (1 to 10 percent).

††† Rust grades below 4 are of no practical importance in grading performance of paints.

+Corresponds to SSPC Initial Surface Condition H (50 to 100 percent).

Table 3
Visual Inspection: 1978 Evaluation

Pile No.	ASTM Rating D 610-68	Comments
13	9	
14	6	Peeling
15	6	Peeling
16	6	Peeling
17	4	
18	9	
19	5	
20	9	
1	Bare	Pitted
4	Bare	Pitted
7	10	Slight blistering on windows
8	10	No blistering on windows
9	10	
10	10	
11	10	
12	3	

Table 4
Potential Measurements: Pilings
With Sacrificial Anode Cathodic Protection

Pile No.	Voltage 1975	Voltage 1976	Voltage 1977	Voltage 1978	Voltage 1979	Voltage 1980
2A	-1.05	-1.06	-1.08	-1.03		
B	-0.97	-1.00	-1.04	-0.97		
C	-1.05	-1.07	-1.08	-1.03		
3A	-1.04	-1.06	-1.08	-1.01		
B	-0.95	-1.00	-1.03	-0.96		
C	-1.03	-1.06	-1.08	-1.01		
5A	-1.05	-1.06	-1.07	-1.02		
B	-0.96	-1.00	-1.04	-0.96		
C	-1.06	-1.06	-1.06	-0.99		
6A	-1.06	-1.09	-1.09	-1.03		
B	-1.09	-1.09	-1.10	-1.03		
C	-1.07	-1.09	-1.08	-1.03		

Table 5
Buzzards Bay
1977 Data

Location	Anode I_p	Cathode I_q	$\frac{I_p x I_q}{I_p + I_q}$ I_c	$I_p x I_q$	$I_p + I_q$	Depth I_p	Depth I_q
1A	.076A	.051A	.0305	.0039	.1270		
1B	.053	.053	.0265	.0028	.1060		
4A	.060	.080	.0343	.0048	.1400		
4B	.072	.079	.0377	.0057	.1510		
7A	.038	.014	.0102	.0005	.0520		
7B	.039	.025	.0152	.0010	.0640		
8A	.037	.013	.0096	.0005	.0500		
8B	.044	.035	.0195	.0015	.0790		
9A	.035	.021	.0131	.0007	.0560		
9B	.038	.039	.0192	.0015	.0770		
10A	.033	.027	.0149	.0009	.0600		
10B	.041	.039	.0200	.0016	.0800		
11A	.027	.014	.0092	.0004	.0410		
11B	.039	.018	.0123	.0007	.0570		
12A	.062	.041	.0247	.0025	.1030		
12B	.080	.055	.0326	.0044	.1350		
13A	.036	.022	.0137	.0008	.0580		
13B	.052	.033	.0202	.0017	.0850		
14A	.057	.037	.0224	.0021	.0940		
14B	.063	.030	.0203	.0019	.0930		
15A	.025	.014	.0090	.0004	.0390		
15B	.032	.026	.0143	.0008	.0580		
16A	.052	.019	.0141	.0010	.0710		
16B	.055	.032	.0207	.0018	.0870		
17A	.086	.052	.0324	.0045	.1380		
17B	.100	.060	.0375	.0060	.1600		
18A	.058	.050	.0269	.0029	.1080		
19A	.120	.050	.0353	.0060	.1700		
19B	.142	.044	.0336	.0062	.1860		
20A	.032	.017	.0102	.0005	.0490		
20B	.050	.040	.0222	.0020	.0900		
21A	.064	.053	.0288	.0034	.1178		
21B	.060	.080	.0457	.0064	.1400		
22A	.084	.055	.0317	.0044	.1390		
22B	.094	.098	.0479	.0092	.1920		
23A	.025	.0185	.0106	.0005	.0435		
23B	.038	.035	.0182	.0013	.0730		
24B	.038	.035	.0182	.0013	.0730		
25B	.028		.028				
Concrete							
25A		.018	.018				
18B	.505	.028	.0179	.0014	.0780		

Table 6
Buzzards Bay 1978 Data

Location	Anode I_p	Cathode I_q	$\frac{I_p \times I_q}{I_p + I_q}$ I_c	$I_p \times I_q$	$I_p + I_q$	Depth I_p	Depth I_q	$\frac{I_c}{30\ ft^2}$
1A	.051AMPS	.042AMPS	.0226	.0021	.0930			.00075
1B	.046	.043	.0225	.0020	.0890			
4A	.052	.057	.0275	.0030	.1090			
4B	.043	.046	.0225	.0020	.0890			
4C	.048	.045	.0237	.0022	.0930			
7A	.034	.031	.0169	.0011	.0650			
7B	.037	.031	.0162	.0011	.0680			
7C	.051	.045	.0240	.0023	.0960			
8A	.024	.025	.0122	.0006	.0490			
8C	---	.035	.035	---	---			
9A	.040	.030	.0171	.0012	.0700			
9C	.058	.048	.0175	.0028	.1060			
10A	.037	.027	.0156	.0010	.0640			
10C	.057	.044	.0248	.0025	.1010			
11A	.028	.029	.0140	.0008	.0570			
11C	.051	.050	.0257	.0026	.1010			
12A	.055	.053	.0269	.0029	.1080			
12C	.056	.045	.0248	.0025	.1010			
13A	.0395	.038	.0194	.0015	.0775			
13C	.055	.047	.0253	.0026	.1020			
14A	.047	.051	.0245	.0024	.0980			
15A	.037	.031	.0169	.0011	.0680			
(22C)								
16A	---	.035	.035					
(16C)								
16A	.055	.039	.0223	.0021	.0940			
17A	.057	.050	.0271	.0029	.1070			
18A	.044	.052	.0238	.0023	.0960			
18B	---	.043	.043					
18C	---	.050	.050					
19A	.055	.056	.0277	.0031	.1110			
19B	---	.053	.053					
19C	---	.064	.064					
20A	.035	.048	.0205	.0017	.0830			
20B	---	.052	.052					
20C	---	.052	.052					
(22C)								
21A	.054	.056	.0275	.0030	.1100			
21B	---	.055	.055					
21C	---	.060	.060					
22A	.053		.053					

Table 7
Tabulation of CPI 1975-1978

Pile No.	1975	1976	1977	1978
1A	0.0487	.0333	2.78	4.6
B	0.058	0.327	0.058	5.86
C	Aux	Aux	0.89	Aux
4A	0.0472	0.34	0.87	4.55
B	0.0667	0.34	0.058	4.69
C	---	0.321	Aux	6.25
7A	7.65	14.29	11.00	10.38
B	6.21	4.52	6.11	
C	0.19	0.449	1.47	
8A	7.19	14.29	7.50	
B	7.20	2.75	1.96	7.65
C	0.18	0.435	1.62	4.44
9A	6.13	14.29	7.69	6.88
B	7.50	6.38	1.69	7.13
C	0.18	0.459	1.75	5.0
10A	6.0	12.09	3.85	8.92
B	16.16	6.1	3.57	6.5
C	0.19	0.438	1.58	4.38
11A	5.33	12.5	7.50	10.0
B	8.70	4.21	1.85	6.43
C	0.16	0.44	1.57	5.0
12A	*	2.73	1.82	5.2
B	*	1.25	0.213	5.2
C	0.16	0.409	1.48	4.8
13A	5.68	14.29	4.14	7.37
B	15.15	2.65	1.20	6.08
C	0.15	0.458	1.55	4.7
14A	7.65	20.0	2.08	5.56
B	15.18	3.25	0.773	6.0
C	0.17	0.455	1.52	4.79
15A	7.22	11.04	17.86	20.0
B	13.71	2.73	1.53	6.52
C	0.71	0.44	1.49	4.64
16A	*	*	2.34	*
B	*	*	0.556	*
C	0.16	*	1.18	4.5
17A	*	0.669	1.65	*
B	*	*	0.30	*
C	0.15	0.397	1.47	3.04
18A	1.61	*	1.92	*
B	*	1.11	1.19	*
C	0.16	0.484	1.47	4.35
19A	*	*	1.79	*
B	*	*	0.375	*
C	*	*	1.43	5.88
20A	6.36	4.64	9.33	5.2
B	7.39	2.91	2.0	4.17
C	0.23	0.542	1.6	2.89
21A	1.47	2.05	2.06	3.57
B	6.25	2.65	0.619	3.41
C	0.28	0.545	1.52	3.16

Table 7 (Cont'd)
Tabulation of CPI 1975-1978

Pile No.	1975	1976	1977	1978
22A	---	0.378	1.40	3.19
B	---	0.375	0.076	2.95
	Rows 22-24			
C	Aux	Aux	1.49	Aux
				Connection
23A	11.03	31.11	11.50	Broken
B	4.22	8.26	3.13	
C	0.26	0.845	1.88	3.5
			Handles	Connection
24A	22.50	50.0	Broken	Broken
				Connection
B	4.29	4.77	2.50	Broken
C	0.48	1.06	1.50	2.22
25A	---	---	---	
B	---	---	---	

*Initial Potential Reading <-0.85 V (Potential not shift 150 mV more negative).

Table 8
Comparison of Schwerdtfeger's Corrosion Currents; LaCosta/Buzzards Bay

	Bare Steel			Coal Tar Epoxy		
Location (pile system)	LaCosta (1)	Buzzards Bay (1) 1977	Buzzards Bay (1) 1978	LaCosta (7)	Buzzards Bay (10) 1977	Buzzards Bay (10) 1978
I_p, mA	500	76	51	150	33	37
I_q, mA	440	51	42	150	27	27
$(I_p)(I_q)/(I_p+I_q)$	234	30	22	75	15.9	15.6
Average Corrosion Current Density (I_c) in mA/sq ft	2.92	1	.73	.93	.49	.52

40

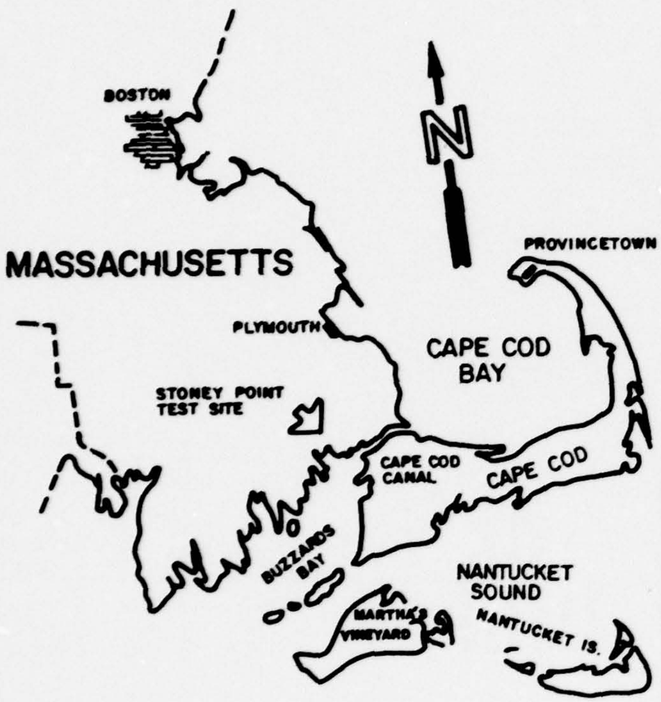


Figure 1. Buzzards Bay.

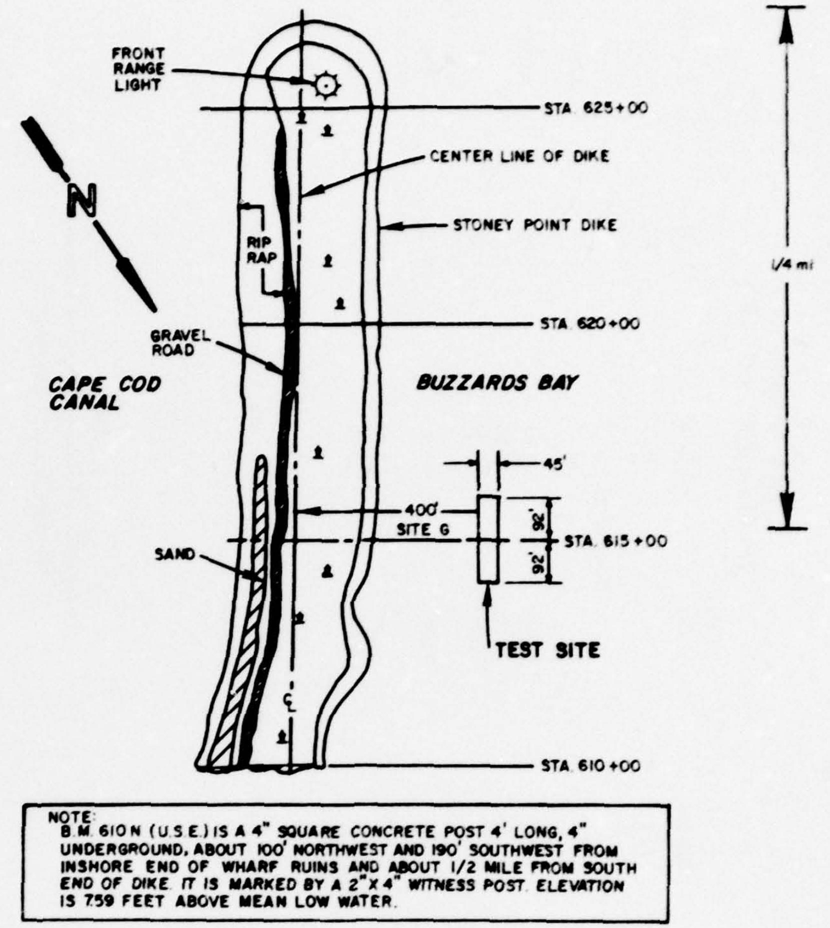
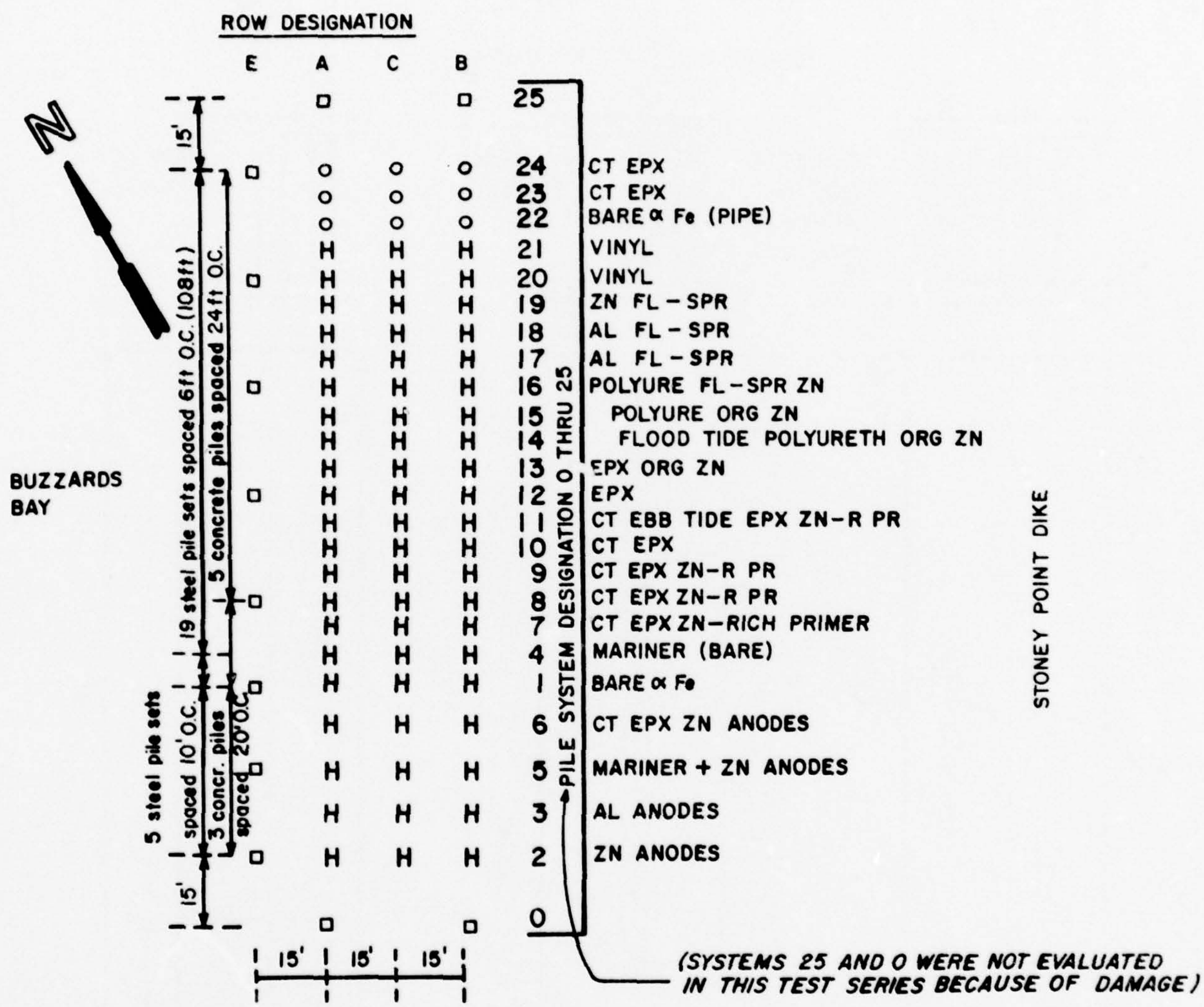


Figure 2. Buzzards Bay test site location.



SYMBOLS: H DENOTES HP 8" x 8" x 36LB. STEEL PILES
O DENOTES 8" DIA. SCH. 40 STEEL PIPE PILES
□ DENOTES 12" SQ. PRESTRESSED CONCRETE PILE (CONTRACTOR FURNISHED)
CT DENOTES COAL TAR
EPX DENOTES EPOXY

Figure 3. Installation plan. (Metric conversion factors:
1 ft = 0.3048 m; 1 in. = 2.54 cm; 1 lb = 0.4536 kg.)

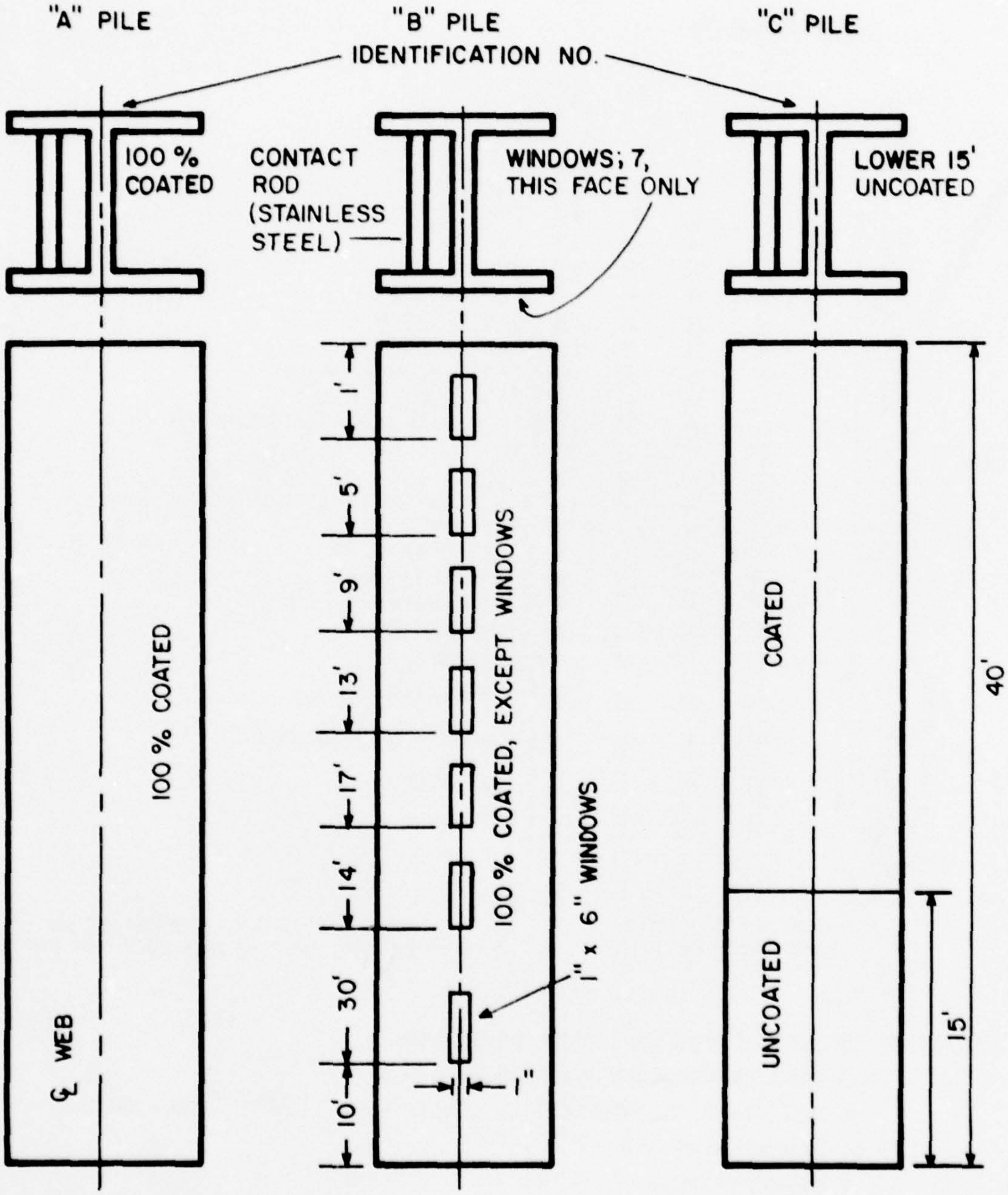


Figure 4. H-piling coating detail. (Metric conversion factors: 1 ft = 0.3048 m; 1 in. = 2.54 cm.)

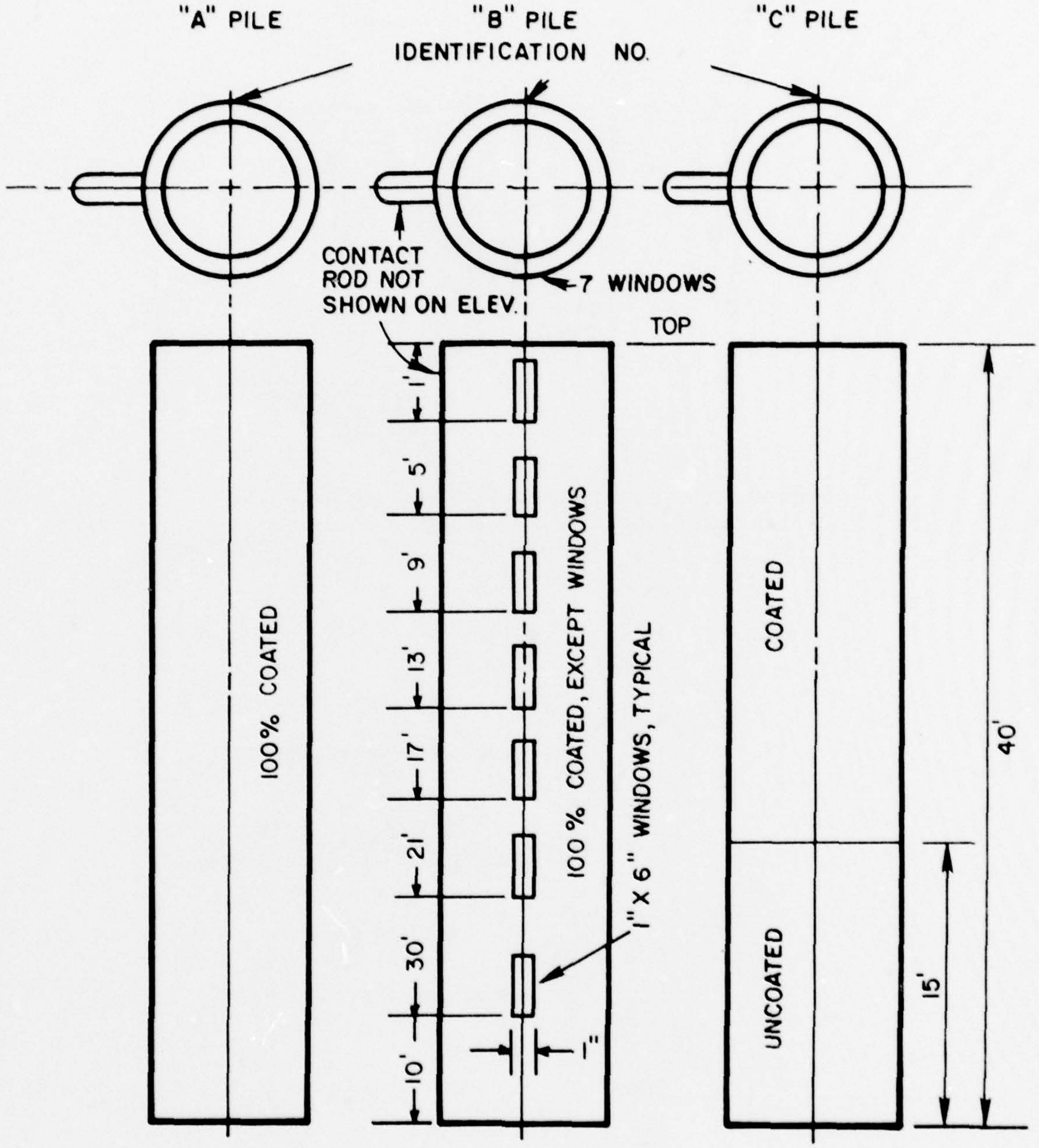


Figure 5. Pipe piling coating detail. (Metric conversion factors: 1 ft = 0.3048 m; 1 in. = 2.54 cm.)

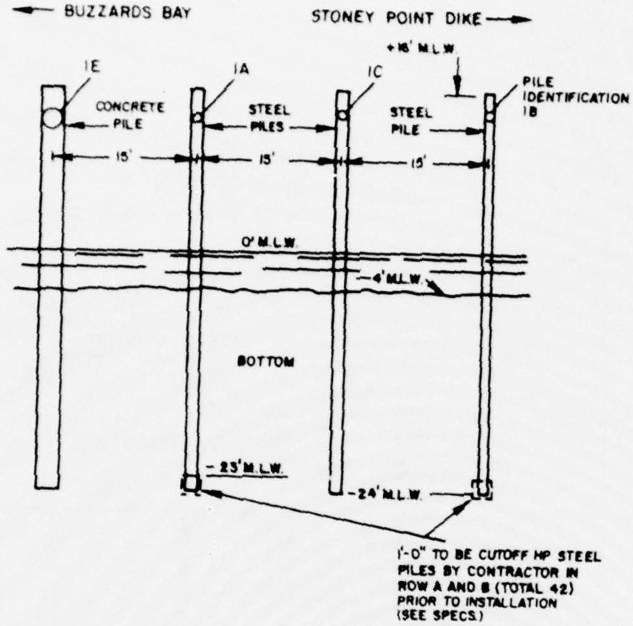


Figure 6. Piling system at Buzzards Bay. (Metric conversion factors: 1 ft = 0.3048 m; 1 in. = 2.54 cm.)

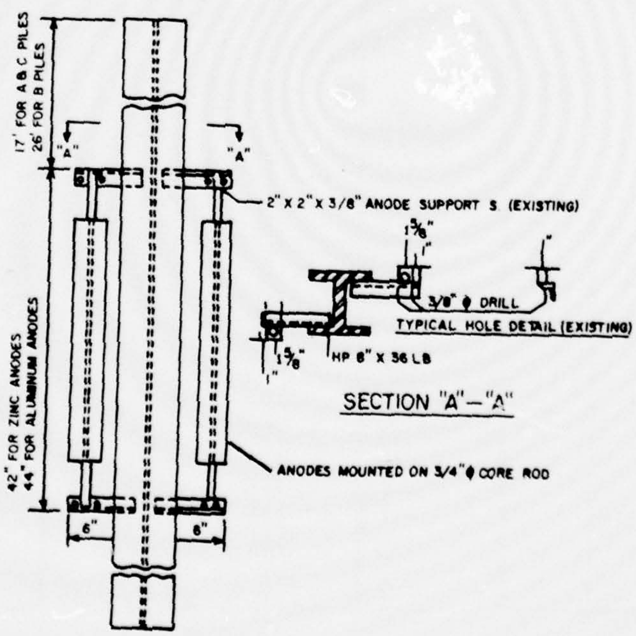


Figure 7. Anode mounting detail. (Metric conversion factors: 1 ft = 0.3048 m; 1 in. = 2.54 cm.)

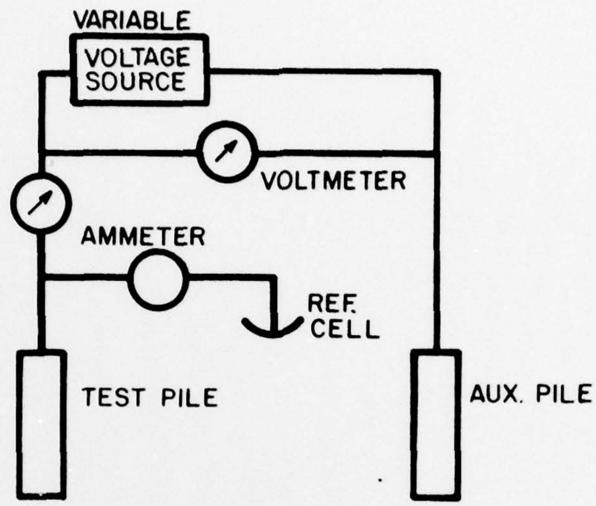


Figure 8. Electric circuit for polarization measurements.

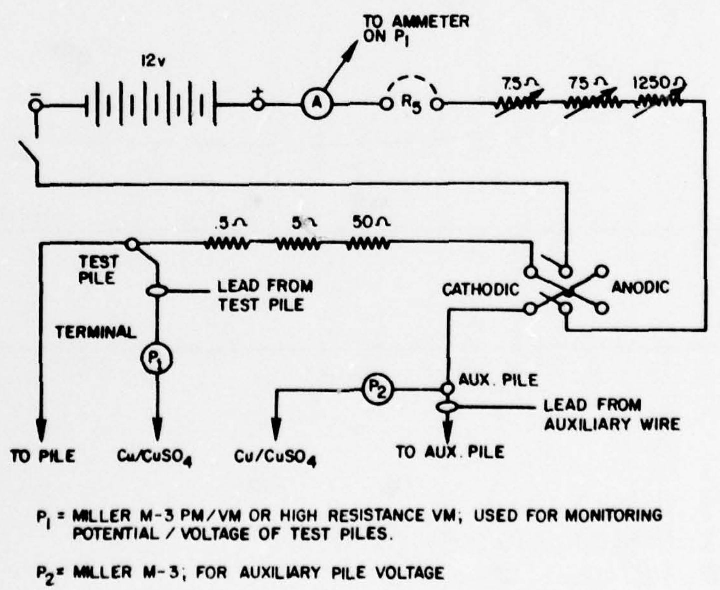


Figure 9. Circuit diagram for measurements of cathodic protection index.

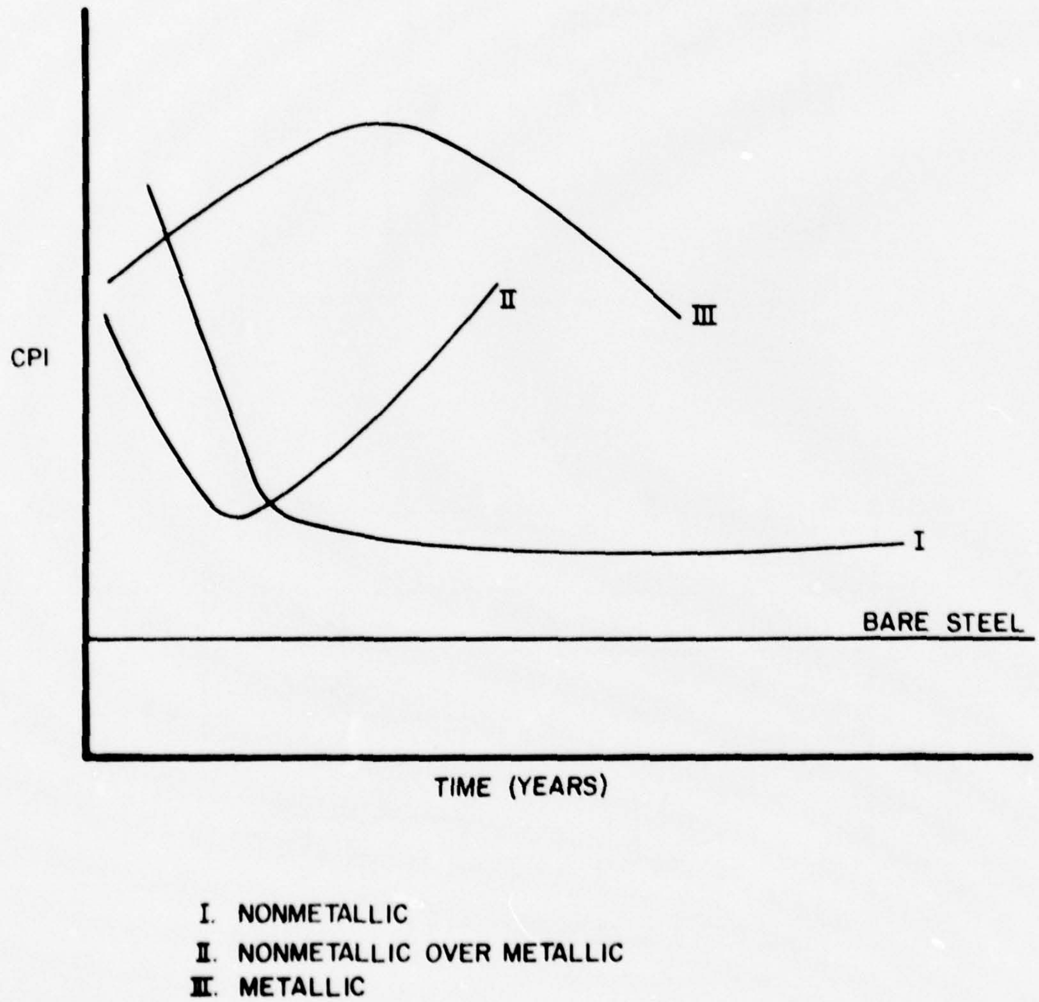


Figure 10. Characteristic curves for various generic coating systems.

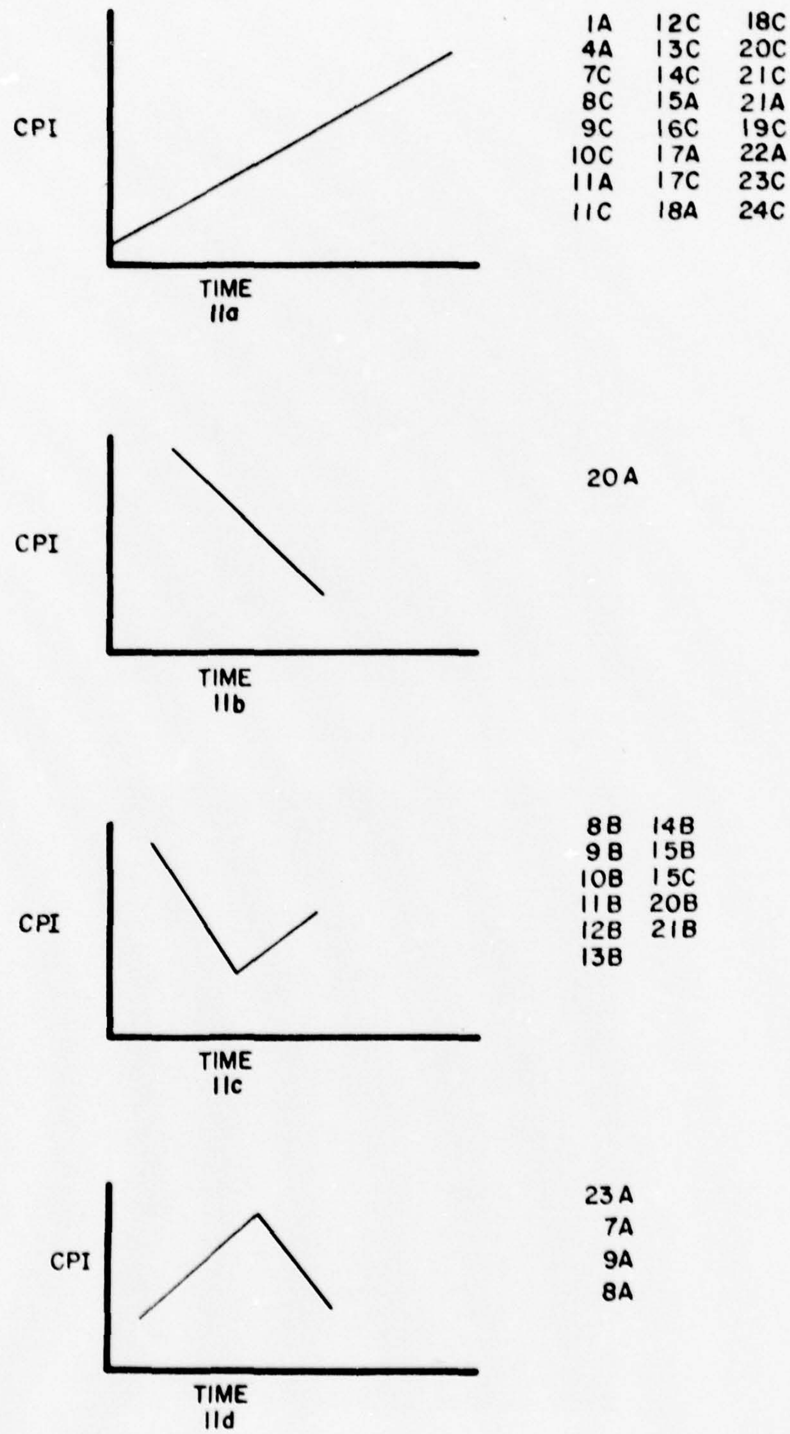
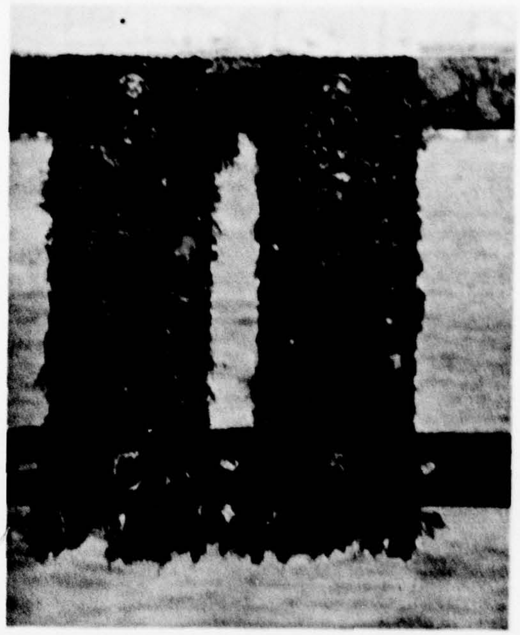
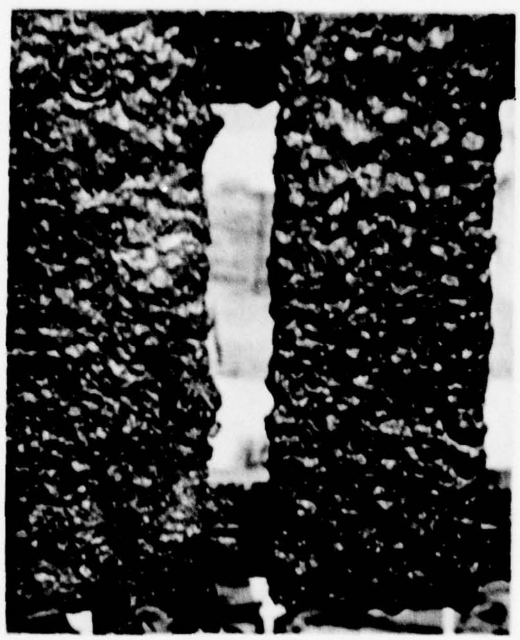


Figure 11. Characteristic CPI/time curves for piles at Buzzards Bay collated with individual piles.



a. 3 months



b. 9 months

Figure 12. The 5-year sequence of fouling on carbon steel in seawater.

c. 18 months

d. 36 months

Figure 12 (Cont'd)

e. 48 months

f. 60 months

Figure 12 (Cont'd)

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APPENDIX A: POLARIZATION PLOTS AND TAFEL EXTRAPOLATIONS

POLARIZATION DATA
SEPTEMBER 1978

	1A		1B		1C	
I	Potential volts		Potential volts		Potential volts	
amps	CATH	ANODIC	CATH	ANODIC	CATH	ANODIC
0	.64	.69	.635	.685	.615	.675
.0085	—				—	.635
.0088	—			.65		
.009	.68		.675		.655	
.0092	—	.655	—			
.01	—	.65	—	.645	.66	.63
.015	.705	.63	0.7	.625	.68	.61
.02	.725	.61	.725	.605	.7	.59
.03	.77	.565	.775	.56	.74	.545
.04	.82	.525	.815	.515	.79	.505
.05	.865	.48	.865	.475	.83	.46
.06	.905	.44	.905	.43	.87	.415
.07	.95	.395	.945	.39	.915	.375
.08	1.05	.36	.99	.35	.955	.335
.09	1.10	.32	1.04	.31	1.0	.29
.10	1.14	.265	1.11	.265	1.06	.25
.11	1.14	.225	1.13	.225	1.1	.2
.12	1.18	.172	1.18	1.75	1.15	.16
.13	1.23	.129	—	.13	1.19	.115
.14	1.27	.082	—	.085	1.23	.075
.15	—	.044	—	.06	1.28	—
.158	—	—	—	—	—	0
.160	—	.002	—	—	—	—
.162		—	—		—	—

	4B			4C	
I	Potential volts		I	Potential volts	
amps	CATH	ANODIC	amps	CATH	ANODIC
0	0.61	.68	0	.61	.67
.0087		.645	.0087	.65	.63
.009	.65		.009		
.01	.655	.635	.01	.655	.625
.02	.7	.6	.015	.675	.585
.03	.74	.545	.02	.70	.54
.04	.78	.5	.03	.74	.5
.05	.825	.46	.04	.785	.455
.06	.87	.415	.05	.83	.415
.07	.91	.375	.06	.87	.37
.08	.95	.33	.07	.91	.33
.09	.99	.28	.08	.955	.29
.1	1.05	.25	.09	.99	.245
.11	1.1	.2	.1	1.06	.2
.12	1.14	.16	.11	1.1	.16
.13	1.18	.12	.12	1.15	.11
.14	1.23		.13	1.19	.07
.15	1.26	.075	.14	1.22	.035
.159	—	0	.15	1.28	—
.6	1.32	—	.158	—	0

7A

I amps	Potential volts CATH	ANODIC
0	.62	.695
.0088	.675	–
.009	–	.64
.01	–	.625
.015	.72	.6
.02	.75	.565
.03	.81	.5
.04	.89	.435
.05	.96	.375
.06	1.08	.315
.07	1.18	.255
.08	1.25	.19
.09	1.32	.13
.1	1.4	.06
.11	–	.0015
.111	–	0

7B

I amps	Potential volts CATH	ANODIC
0	.61	.71
.0088	.665	–
.009	–	.65
.01	.67	.64
.015	.700	.61
.02	.725	.575
.03	.775	.51
.04	.84	.45
.05	.9	.38
.06	.95	.33
.07	1.04	.27
.08	1.10	.21
.09	1.17	.15
.1	1.23	.09
.11	1.3	.025
.113	–	0
.12	1.38	–

7C

I amps	Potential volts CATH	ANODIC
0	.695	.74
.0087	.735	–
.009	–	.7
.01	.74	.7
.015	.76	.675
.02	.785	.655
.03	.83	.61
.04	.875	.565
.05	.92	.52
.06	.96	.48
.07	1.03	.43
.08	1.08	.39
.09	1.13	.35
.1	1.17	.3
.11	1.21	.255
.12	1.25	.215
.13	1.3	.17
.14	1.35	.125
.15	1.39	–
.17		0

8A

I amps	Potential volts CATH	ANODIC
0	.635	0.66
.0085	–	.62
.009	.68	
.010	.72	.6
.015	.75	.56
.02	.82	.51
.03	.87	.45
.04	.95	.4
.05	1.0	.34
.06	1.06	.28
.07	1.1	.24
.08	1.18	.19
.09	1.22	.14
.10	1.28	.09
.116	–	0
.15	1.52	–
.20	1.76	–

8C

I amps	Potential volts CATH	ANODIC
0	.785	
.0088	.771	
.01	.778	
.015	.8	
.02	.82	
.03	.865	
.04	.91	
.05	.95	
.06	.99	
.07	1.04	
.08	1.08	
.09	1.13	
.1	1.17	
.11	1.22	

9A

I amps	Potential volts CATH	ANODIC
0	.67	.66
.0085	.72	–
.009	–	.62
.010	.74	.61
.015	.75	.58
.02	.78	.55
.03	.84	.5
.04	.88	.44
.05	.96	.38
.06	1.02	.35
.07	1.08	.3
.08	1.12	.25
.09	1.18	.2
.10	1.22	.15
.134	–	0
.15	1.44	–
.20	1.68	–

9C

I amps	Potential volts CATH	ANODIC
0	.735	.73
.0089	.775	–
.009	–	.69
.01	.78	.685
.015	.8	.665
.02	.825	.645
.03	.865	.6
.04	.91	.555
.05	.95	.51
.06	.99	.47
.07	1.05	.415
.08	1.09	.38
.09	1.13	.34
.1	1.18	.29
.11	1.22	.25
.12	1.26	.205
.13	1.3	.156
.14	1.35	.107
.15	–	.068
.16	–	.025
.167	–	0

10A

I amps	Potential volts CATH	ANODIC
0	.650	.65
.0085	.7	.6
.009		.6
.010	.72	.6
.015	.74	.57
.020	.77	.54
.030	.845	.48
.04	.9	.43
.05	.97	.375
.06	1.04	.31
.07	1.1	.25
.08	1.16	.2
.09	1.24	.14
.10	1.3	.09
.116		0
.15	1.56	
.20	1.78	

10C

I amps	Potential volts CATH	ANODIC
0	.74	.75
.0088	.78	
.009		.71
.01	.795	.705
.015	.82	.68
.02	.84	.66
.03	.88	.615
.04	.92	.575
.05	.965	.53
.06	1.01	.485
.07	1.06	.445
.08	1.1	.4
.09	1.15	.36
.1	1.2	.31
.11	1.23	.27
.12	1.28	.225
.13	1.32	.18
.14	1.36	.13
.15	1.405	.087
.16	–	.045
.171	–	0

11A

I amps	Potential volts CATH	ANODIC
0	0.6	.58
.009	.65	.54
.01	.68	.53
.015	.72	.5
.02	.75	.46
.03	.82	.41
.04	.89	.35
.05	.95	.26
.06	1.02	.2
.07	1.1	.15
.08	1.16	.08
.09	1.22	.02
.95	–	0
.10	1.28	–
.15	1.56	–
.20	1.8	–

11C

I amps	Potential volts CATH	ANODIC
0	.715	.71
.008	.755	.67
.01	.76	.665
.015	.78	.645
.02	.8	.625
.03	.845	.58
.04	.89	.535
.05	.93	.495
.06	.97	.45
.07	1.02	.405
.08	1.07	.36
.09	1.105	.32
.10	1.15	.28
.11	1.2	.23
.12	1.24	.177
.13	1.28	.14
.14	1.33	.09
.15	1.36	.055
.16	–	.01
.183	–	.00

12A

I amps	Potential volts CATH	ANODIC
0	0.64	.64
.009	.67	.61
.010	.675	.61
.015	.7	.6
.020	.72	.58
.030	.75	.55
.040	.78	.51
.050	.82	.48
.060	.85	.45
.07	.89	.41
.08	.92	.38
.09	.95	.35
.10	.985	.31
.15	1.145	.14
.196	–	0
.12	–	

12C

I amps	Potential volts CATH	ANODIC
0	.73	.73
.008	.77	
.009		.69
.010	.78	.685
.015	.8	.665
.02	.82	.645
.03	.86	.6
.04	.9	.56
.05	.945	.575
.06	.985	.47
.07	1.04	.43
.08	1.08	.39
.09	1.12	.35
.10	1.17	.3
.11	1.22	.26
.12	1.25	.215
.13	1.3	.175
.14	1.34	.13
.15	1.38	.079
.16	–	.07
.17	–	.0

13A

I amps	Potential volts CATH	ANODIC
0	0.63	
.009	.68	
.010	.68	
.015	.72	
.02	.74	
.03	.78	
.04	.84	
.05	.88	
.06	.95	
.07	1.0	
.08	1.04	
.09	1.1	
.10	1.14	
.142	–	
.15	1.36	
.20	1.56	

13C

I amps	Potential volts CATH	ANODIC
0	.73	.73
.008	.77	–
.0091	–	.69
.01	.775	.685
.015	.795	.67
.02	.815	.645
.03	.86	.6
.04	.9	.56
.05	.945	.515
.06	.985	.47
.07	1.04	.43
.08	1.09	.385
.09	1.13	.345
.10	1.17	.3
.11	1.22	.255
.12	1.25	.21
.13	1.3	.165
.14	1.34	.14
.15	1.38	.075
.168	–	0

14A

I amps	Potential volts CATH	ANODIC
0	0.63	0.62
.009	.66	.58
.010	.665	.58
.015	.68	.57
.02	.7	.55
.03	.73	.51
.04	.76	.47
.05	.8	.44
.06	.84	.40
.07	.88	.365
.08	.92	.33
.09	.95	.28
.10	1.0	.26
.15	1.18	.08
.176	–	0
.20	1.36	–

15A

I amps	Potential volts CATH	ANODIC
0	.65	0.62
.008	—	.55
.0085	.79	
.010	.795	.55
.015	.83	.52
.02	.86	.48
.03	.92	.44
.04	.99	.38
.05	1.06	.32
.06	1.1	.27
.07	1.18	.22
.08	1.24	.15
.09	1.3	.10
.10	1.34	.05
.11	—	0
.15	1.6	—
.20	1.82	—

16A

I amps	Potential volts CATH	ANODIC
0	0.89	.88
.0085	.93	.84
.010	.93	.83
.015	.95	.81
.02	.97	.78
.03	1.0	.74
.04	1.06	.7
.05	1.1	.66
.06	1.14	.62
.07	1.18	.57
.08	1.22	.52
.09	1.265	.48
.10	1.3	.45
.15	1.5	.24
.20	1.7	.04

17A

I amps	Potential volts CATH	ANODIC
0	0.77	0.795
.0085	.795	.765
.010	.8	.76
.015	.82	.74
.02	.83	.73
.03	.85	.68
.04	.9	.66
.05	.925	.625
.06	.96	.58
.07	.985	.56
.08	1.02	.53
.09	1.06	.49
.10	1.1	.46
.15	1.24	.28
.20	1.4	.12

18A

I amps	Potential volts CATH	ANODIC
0	.8	0.79
.008		.76
.009	.83	
.010	.84	.75
.015	.85	.74
.02	.87	.72
.03	.9	.68
.04	.94	.65
.05	.97	.61
.06	1.0	.57
.07	1.03	.54
.08	1.08	.51
.08	1.12	.46
.10	1.16	.42
.15	1.34	.25
.20	1.52	.06

18B

I amps	Potential volts CATH
0	.79
.008	.76
.01	.75
.015	.74
.02	.72
.03	.68
.04	.65
.05	.61
.06	.57
.07	.54
.08	.51
.09	.46
.10	.42
.15	.25
.2	.06

18C

I amps	Potential volts CATH
0	.73
.009	.76
.010	.76
.015	.775
.02	.78
.03	.82
.04	.85
.05	.88
.06	.91
.07	.94
.08	.97
.09	1.0
.1	1.04
.15	1.18
.2	1.34

19A

I	Potential volts	
amps	CATH	ANODIC
0	.72	.85
.009	.8	.82
.010	.81	.815
.015	.82	.79
.02	.84	.77
.03	.87	.74
.04	.9	.7
.05	.93	.66
.06	.96	.63
.07	.985	.59
.08	1.03	.55
.09	1.065	.50
.10	1.1	.46
.15	1.26	.29
.20	1.42	.10

19B

I amps	Potential volts CATH
0	.87
.009	.895
.010	.9
.015	.92
.02	.93
.03	.96
.04	1.0
.05	1.02
.06	1.06
.07	1.1
.08	1.12
.09	1.16
.10	1.18
.15	1.34
.20	1.5

19C

I amps	Potential volts CATH
0	.68
.009	.72
.010	.72
.015	.735
.02	.75
.03	.78
.04	.81
.05	.84
.06	.87
.07	.9
.08	.93
.09	.96
.10	.98
.15	1.14
.20	1.3

20A

I amps	Potential volts CATH	ANODIC
0	.62	.645
.008	–	.6
.009	.66	
.010	.665	.58
.015	.72	.565
.02	.75	.54
.03	.8	.49
.04	.85	.44
.05	.88	.4
.06	.92	.35
.07	.97	.3
.08	1.045	.26
.09	1.1	.22
.10	1.16	.17
.142	–	0
.150	1.38	–
.20	1.58	–

20B

I amps	*Potential volts* CATH
0	.61
.009	.65
.010	.655
.015	.67
.02	.69
.03	.73
.04	.77
.05	.82
.06	.85
.07	.88
.08	.92
.09	.97
.10	1.02
.15	1.22
.20	1.4

20C

I amps	Potential volts CATH
0	.65
.009	.68
.010	.685
.015	.7
.02	.715
.03	.75
.04	.78
.05	.81
.06	.84
.07	.87
.08	.9
.09	.93
.10	.96
.15	1.12
.20	1.28

21A

I amps	Potential volts CATH	Potential volts ANODIC
0	.63	.64
.0085	.665	
.009	—	.6
.010	.665	.6
.015	.67	.58
.020	.7	.56
.03	.73	.53
.04	.77	.48
.05	.8	.45
.06	.83	.42
.07	.865	.38
.08	.9	.35
.09	.94	.31
.10	.97	.27
.15	1.128	.1
.178	—	0
.20	1.32	—

21B

I amps	Potential volts CATH
0	.67
.0085	.695
.010	.7
.015	.71
.02	.72
.03	.77
.04	.8
.05	.835
.06	.87
.07	.9
.08	.92
.09	.97
.10	1.0
.15	1.16
.20	1.34

21C

I amps	Potential volts CATH
0	.675
.0085	.7
.010	.71
.015	.72
.02	.74
.03	.77
.04	.8
.05	.83
.06	.865
.07	.89
.08	.92
.09	.95
.10	.98
.15	1.14
.20	1.3
.25	

22A

I amps	Potential volts ANODIC
0	.64
.009	.62
.010	.62
.015	.6
.02	.58
.03	.55
.04	.52
.05	.48
.06	.45
.07	.43
.08	.39
.09	.365
.10	.335
.15	.18
.20	.02

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1A

I amps	Potential volts CATH	ANODIC
0	.70	.69
.007	.705	.68
.010	.710	.675
.015	.72	.67
.02	.76	.66
.03	.77	.65
.04	.79	.635
.05	.80	.62
.06	.81	.61
.07	.79	.60
.08	.80	.58
.09	.81	.57
.10	.83	.56
.15	.89	.49
.20	.95	.425
.30	1.09	.295

1B

I amps	Potential volts CATH	ANODIC
0	.69	.68
.007	.70	.67
.010	.70	.67
.015	.71	.66
.020	.715	.655
.03	.73	.64
.04	.74	.63
.05	.75	.615
.06	.765	.605
.07	.78	.59
.08	.79	.575
.09	.81	.56
.10	.82	.55
.15	.88	.485
.2	.94	.42
.3	1.08	.29

4A

I amps	Potential volts CATH	ANODIC
.0	.675	.67
.007	.685	.66
.010	.69	.655
.015	.695	.65
.02	.70	.64
.03	.715	.63
.04	.73	.62
.05	.74	.605
.06	.75	.59
.07	.765	.58
.08	.78	.565
.09	.79	.55
.10	.81	.54
.12	—	.51
.15	.87	.47
.2	.93	.41
.3	1.06	.28
.4	1.18	.15

4B

I amps	Potential volts CATH	ANODIC
.0	.68	.67
.007	.69	.66
.110	.69	.66
.015	.70	.65
.02	.705	.645
.03	.72	.63
.04	.73	.62
.05	.74	.605
.06	.755	.59
.07	.77	.58
.08	.78	.57
.09	.795	.555
.10	.81	.54
.12	.83	.51
.15	.87	.47
.20	.93	.41
.30	1.06	.28
.40	1.19	.15

7A		
I	Potential volts	
amps	CATH	ANODIC
0	.75	.66
.007	.78	.64
.010	.83	.625
.011	.85	–
.012	.875	.62
.013	.885	–
.014	.89	–
.015	.90	.61
.02	.925	.595
.03	.96	.57
.04	1.00	.53
.05	1.06	.505
.06	1.10	.48
.07	1.14	.45
.08	1.18	.43
.09	1.23	.40
.10	1.28	.38
.12	1.34	.335
.15	1.44	.27

7B		
I	Potential volts	
amps	CATH	ANODIC
0	.74	.695
.007	.765	.67
.010	.78	.66
.011	.79	–
.012	.80	.655
.013	.805	–
.014	.81	–
.015	.82	.64
.02	.84	.63
.03	.875	.60
.04	.91	.575
.05	.94	.555
.06	.97	.52
.07	1.02	.49
.08	1.06	.47
.09	1.10	.445
.10	1.14	.42
.12	1.18	.375
.15	1.26	.30

8A		
I	Potential volts	
amps	CATH	ANODIC
0	.74	.76
.007	.76	.73
.010	.77	.72
.012	.78	–
.015	.79	.705
.017	.80	–
.02	.815	.685
.03	.86	.665
.04	.88	.62
.05	.91	.595
.06	.94	.565
.07	.97	.54
.08	1.02	.515
.09	1.06	.49
.10	1.08	.465
.12	1.13	.425
.15	1.2	.36
.20	–	.26

8B		
I	Potential volts	
amps	CATH	ANODIC
0	.74	.665
.007	.77	.63
.010	.805	.62
.012	.83	–
.015	.865	.605
.017	.89	–
.02	.905	.59
.03	.945	.56
.04	.98	.53
.05	1.03	.50
.06	1.07	.475
.07	1.12	.45
.08	1.16	.42
.09	1.20	.39
.10	1.24	.37
.12	1.32	.32
.15	1.40	.25
.20	–	.14

9A

I amps	Potential volts CATH	ANODIC
0	.75	.74
.007	.77	.715
.010	.79	.68
.012	.805	–
.015	.825	.66
.017	.84	–
.02	.865	.64
.03	.905	.61
.04	.94	.58
.05	.98	.545
.06	1.03	.51
.07	1.08	.48
.08	1.12	.45
.09	1.16	.42
.10	1.20	.39
.12	1.26	.335
.15	1.35	.250
.20	1.52	.12
.25	1.64	–

9B

I amps	Potential volts CATH	ANODIC
0	.71	.71
.007	.73	.69
.010	.74	.68
.012	.75	–
.015	.76	.665
.017	.77	–
.02	.78	.65
.03	.81	.62
.04	.84	.59
.05	.87	.56
.06	.90	.535
.07	.93	.51
.08	.965	.485
.09	.995	.46
.10	1.04	.43
.12	1.09	.385
.15	1.16	.315
.20	1.28	.20
.25	1.39	–

10A

I amps	Potential volts CATH	ANODIC
0	.72	.67
.007	.74	.655
.01	.745	.65
.12	.755	–
.015	.76	.635
.02	.775	.62
.03	.80	.60
.04	.83	.58
.05	.86	.555
.06	.885	.53
.07	.93	.51
.08	.96	.485
.09	1.00	.46
.10	1.04	.43
.12	–	.39
.15	1.15	.335
.20	1.28	.24
.25	1.39	.14

10B

I amps	Potential volts CATH	ANODIC
0	.75	.655
.007	.775	.63
.010	.79	.62
.012	.80	–
.015	.82	.60
.02	.845	.59
.03	.88	.565
.04	.92	.53
.05	.96	.495
.06	1.00	.455
.07	1.05	.435
.08	1.09	.405
.09	1.14	.38
.10	1.18	.355
.12	–	.30
.15	1.34	.22
.20	1.49	.12
.25	1.61	0.00

11A

I amps	Potential volts CATH	Potential volts ANODIC
0	.655	.60
.007	.695	.57
.010	.75	.56
.012	—	.55
.015	.80	.54
.02	.845	.52
.03	.91	.48
.04	.97	.445
.05	1.05	.405
.06	1.12	.365
.07	—	.325
.08	—	.29
.09	—	.26
.10	—	.225
.11	—	.185
.12	—	.15

11B

I amps	Potential volts CATH	Potential volts ANODIC
0	.68	.66
.007	.70	.64
.008	.705	—
.009	.71	—
.010	.715	.625
.012	—	.62
.015	.73	.61
.020	.75	.59
.025	.775	—
.03	.80	.565
.04	.835	.54
.05	.875	.51
.06	.91	.48
.07	—	.45
.08	—	.425
.09	—	.40
.10	—	.37
.11	—	.34
.12	—	.315
.15	—	.25
.17	—	.195
.20	—	.12

12A

I amps	Potential volts CATH	Potential volts ANODIC
0	.725	.71
.007	.74	.695
.010	.745	.69
.020	.765	.675
.025	.775	—
.03	.79	.66
.04	.81	.64
.05	.835	.62
.06	.86	.605
.07	.88	.59
.08	.905	.57
.09	.93	.555
.10	.95	.53
.12	—	.50
.15	1.06	.46
.20	1.14	.38
.25	—	.31
.3	—	.24
.4	—	.008

12B

I amps	Potential volts CATH	Potential volts ANODIC
0	.715	.70
.007	.73	.69
.01	.73	.68
.02	.745	.67
.025	.75	—
.03	.76	.66
.04	.775	.64
.05	.79	.63
.06	.805	.615
.07	.82	.60
.08	.835	.585
.09	.85	.57
.10	.87	.56
.12	—	.53
.15	.94	.49
.20	1.02	.43
.25	—	.35
.30	1.16	.285
.40	—	.15

13A

I amps	Potential volts CATH	ANODIC
0	.72	.70
.007	.755	.68
.008	–	.67
.009	–	.665
.010	.78	.66
.012	–	.65
.015	–	.64
.017	–	.63
.020	.84	.62
.025	.875	.600
.03	.91	.585
.04	.955	.555
.05	1.00	.52
.06	1.06	.49
.07	–	.46
.08	–	.430
.09	–	.405
.10	–	.37
.15	–	.25
.20	–	.135

13B

I amps	Potential volts CATH	ANODIC
0	.725	7.05
.007	.74	.69
.008	.75	–
.009	.755	–
.010	.76	.68
.015	.77	–
.020	.79	.65
.025	.81	–
.03	.83	.63
.04	.86	.61
.05	.89	.59
.06	.92	.565
.07	.95	.545
.08	.98	.52
.09	1.02	.50
.10	1.06	.475
.12	–	.435
.15	1.16	.375
.20	–	.28
.25	–	.19
.30	–	.10

14A

I amps	Potential volts CATH	ANODIC
0	.72	.68
.005	–	.675
.007	.74	.67
.010	–	.67
.015	.75	.66
.02	.76	.645
.03	–	.62
.04	–	.60
.05	.81	.58
.06	–	.55
.07	.87	.53
.08	–	.51
.09	–	.49
.10	.93	.465
.13	–	.42
.15	–	.37
.20	1.06	.26

14B

I amps	Potential volts CATH	ANODIC
0	.71	.72
.005	.72	.70
.007	–	.68
.010	.74	.68
.015	.75	.665
.02	.76	.65
.03	.78	.625
.04	–	.60
.05	.83	.57
.06	–	.55
.07	.87	.52
.08	–	.50
.09	–	.48
.10	.94	.455
.15	–	.35
.20	1.13	.25
.25	–	.16
.30	–	.065

15A

I amps	Potential volts CATH	Potential volts ANODIC
0	.73	.65
.005	.73	.64
.010	.82	.61
.015	.86	.60
.02	.89	.575
.025	–	.555
.03	.95	.55
.04	1.03	.51
.05	1.08	.47
.06	1.12	.445
.07	1.26	.41
.08	–	.38
.09	–	.355
.10	–	.33
.15	–	.22
.17	–	.17
.20	–	.10
.25	–	.01

15B

I amps	Potential volts CATH	Potential volts ANODIC
0	.72	.73
.005	.74	.705
.010	.75	.68
.015	.77	.66
.02	.78	.65
.03	.81	.62
.04	–	.58
.05	.87	.55
.06	–	.53
.07	.92	.50
.08	–	.47
.09	–	.45
.10	.98	.42
.12	–	.37
.15	–	.30
.17	–	.25
.20	1.22	.18
.25	–	.08

16A

I amps	Potential volts CATH	Potential volts ANODIC
0	.97	.90
.005	.98	.90
.010	.99	.89
.015	1.0	.88
.02	1.02	.87
.03	1.05	.85
.04	1.07	.83
.05	1.09	.80
.06	1.12	.78
.07	–	.755
.08	–	.73
.09	–	.70
.10	–	.675
.13	–	.60
.15	–	.56
.18	–	.50
.20	–	.45
.25	–	.36
.30	–	.26
.35	–	.17
.40	–	.09

16B

I amps	Potential volts CATH	Potential volts ANODIC
0	.98	.975
.005	.99	.965
.010	1.0	.95
.015	1.02	.94
.02	1.03	.93
.03	1.04	.905
.04	1.07	.88
.05	1.08	.855
.06	1.10	.83
.07	–	.80
.08	1.14	.78
.09	–	.75
.10	1.18	.72
.12	–	.67
.15	–	.61
.20	–	.5
.25	–	.41
.30	–	.3
.40	–	.11

17A

I amps	Potential volts CATH	Potential volts ANODIC
0	.86	.85
.005	.865	.84
.010	.87	–
.015	.875	–
.02	.88	.81
.03	.89	–
.04	.90	.78
.05	.915	.75
.06	.93	–
.07	.94	.72
.08	.95	–
.09	.97	–
.10	.98	.68
.12	1.02	.625
.15	1.06	.565
.17	–	.53
.20	1.12	.45
.25	–	.37
.30	1.24	.28
.35	–	.20
.40	–	.11
.45	–	.04

17B

I amps	Potential volts CATH	Potential volts ANODIC
0	.86	.85
.005	.865	.845
.010	.87	–
.015	.875	–
.02	.88	.82
.03	.89	–
.035	–	.80
.04	.90	–
.05	.915	.77
.06	.93	–
.07	.94	.75
.08	.95	.72
.09	.97	.70
.10	.98	.685
.12	1.02	.65
.15	1.06	.60
.17	–	.57
.20	1.12	.52
.25	–	.45
.30	1.24	.36
.35	–	.27
.46	–	.19
.45	–	.11
.50	–	.03

18A

I amps	Potential volts CATH	Potential volts ANODIC
0	.88	.875
.005	.885	.865
.010	.89	–
.015	.90	–
.02	.91	.83
.03	.92	–
.04	.95	.80
.05	.95	.77
.06	.97	–
.07	.985	.725
.08	1.04	.70
.09	1.06	.67
.10	1.10	.65
.12	–	.59
.13	–	.56
.15	1.16	.51
.17	–	.47
.20	1.24	.41
.25	–	.33
.30	–	.25
.35	–	.16
.40	–	.07

18B

I amps	Potential volts CATH	Potential volts ANODIC
0	.89	.88
.005	.90	.87
.010	.905	–
.015	.915	.85
.02	.925	.83
.03	.95	.80
.04	.975	–
.05	1.00	.75
.06	1.04	.72
.07	1.06	.70
.08	1.08	–
.09	1.1	.65
.10	1.12	.62
.12	–	.57
.13	–	.54
.14	–	.50
.15	1.22	–
.16	–	.46
.18	–	.43
.20	–	.38
.25	–	.32
.30	–	.23
.35	–	.14
.40	–	.115
.45	–	.09

19A

I amps	Potential volts CATH	ANODIC
0	.905	.905
.005	.91	.905
.010	.92	–
.015	.92	–
.02	.93	.89
.03	.94	–
.04	.95	.86
.05	.96	–
.06	.97	–
.07	.99	.83
.08	1.0	–
.09	1.03	–
.10	1.04	.79
.13	–	.76
.14	–	.73
.15	1.1	–
.20	–	.65
.25	–	.57
.30	–	.50
.35	–	.43
.40	–	.37
.45	–	.31
.50	–	.24
.55	–	.185
.60	–	.12
.65	–	.07

19B

I amps	Potential volts CATH	ANODIC
0	.99	.995
.005	.99	.99
.010	1.01	–
.015	1.02	.97
.02	1.02	–
.03	1.03	–
.04	1.04	.95
.05	1.06	–
.06	1.07	–
.07	1.08	–
.08	1.1	.90
.09	1.11	–
.10	1.13	.87
.12	–	.85
.15	1.18	–
.16	–	.80
.19	–	.765
.20	–	.75
.25	–	.70
.30	–	.62
.35	–	.55
.40	–	.50
.45	–	.435
.50	–	.365
.55	–	.31
.60	–	.25
.65	–	.20
.70	–	.15

20A

I amps	Potential volts CATH	ANODIC
0	.72	.66
.005	.755	.65
.010	.81	.63
.015	.85	–
.02	.88	.59
.03	.93	–
.04	.98	.53
.05	1.06	.50
.06	1.11	–
.07	1.18	.45
.08	1.22	.41
.09	1.26	–
.10	1.3	.365
.12	–	.315
.14	–	.27
.15	1.43	.24
.17	–	.20
.18	–	.17
.20	–	.13
.25	–	.03

20B

I amps	Potential volts CATH	ANODIC
0	.71	.69
.005	.72	.68
.010	.735	–
.015	.75	.65
.02	.76	.65
.03	.785	–
.04	.81	.6
.05	.83	.57
.06	.86	–
.07	.885	–
.08	.91	.51
.09	.93	–
.10	.955	.45
.13	–	.39
.14	–	.37
.15	1.08	–
.16	–	.32
.18	–	.28
.20	–	.24
.25	–	.15
.30	–	.04

21A

I amps	Potential volts CATH	ANODIC
0	.71	.695
.005	.715	.685
.010	.72	–
.015	.73	–
.02	.74	.65
.03	.75	–
.04	.77	–
.05	.78	.6
.06	.80	.57
.07	.82	.55
.08	.835	–
.09	.85	–
.10	.87	.50
.11	–	.47
.13	–	.435
.15	.95	.395
.17	–	.35
.19	–	.32
.20	1.04	.29
.25	–	.21
.30	–	.11
.35	–	.03

21B

I amps	Potential volts CATH	ANODIC
0	.72	.72
.005	.73	.72
.010	.73	–
.015	.74	–
.02	.75	.685
.03	.76	–
.04	.77	.65
.05	.785	–
.06	.80	–
.07	.81	.60
.08	.825	–
.09	.84	–
.10	.85	.55
.13	–	.49
.15	.91	.45
.18	–	.40
.20	.98	.37
.25	1.06	.30
.27	–	.25
.30	–	.205
.33	–	.15
.35	–	.12
.40	–	.04

22A

I amps	Potential volts CATH	ANODIC
0	.73	.72
.005	.73	.71
.010	.74	–
.015	.74	–
.02	.75	.68
.03	.755	–
.04	.76	–
.05	.77	.65
.06	.78	–
.07	.79	–
.08	.80	.61
.09	.81	–
.10	.82	.58
.14	–	.52
.15	.86	–
.16	–	.5
.18	–	.47
.20	.90	.44
.25	.935	.375
.30	–	.30
.35	–	.23
.40	–	.165
.45	–	.10
.50	–	.03

22B

I amps	Potential volts CATH	ANODIC
0	.735	.73
.005	.74	.72
.010	.745	–
.015	.75	–
.02	.755	.70
.03	.76	–
.04	.77	.675
.05	.78	–
.66	.79	.65
.07	.795	–
.08	.805	.62
.09	.815	–
.10	.825	.59
.13	–	–
.15	.875	–
.16	–	.50
.18	–	.45
.20	.91	–
.25	.94	.38
.30	–	.315
.35	1.04	.245
.40	–	.18
.45	1.13	.11
.50	–	.04

23A

I amps	Potential volts CATH	ANODIC
0	.665	.645
.005	.68	.62
.010	.72	—
.013	.77	.57
.014	.77	—
.015	.785	—
.02	.82	.55
.03	.88	.51
.04	.93	.46
.05	.98	—
.06	1.05	.40
.07	1.10	.36
.08	1.15	—
.09	1.19	.31
.10	1.22	.28
.12	—	.23
.13	—	.20
.15	1.34	.15
.17	—	.11
.18	—	.08
.20	—	.03

23B

I amps	Potential volts CATH	ANODIC
0	.68	.67
.005	.695	.655
.010	.71	—
.015	.725	.62
.020	.74	—
.025	—	.59
.03	.775	—
.040	.81	.55
.05	.845	—
.06	.875	.49
.07	.91	—
.08	.95	.43
.09	.97	—
.10	1.02	.38
.12	—	.32
.14	—	.27
.15	1.16	—
.16	—	.22
.18	—	.17
.20	1.30	.12
.25	—	.02

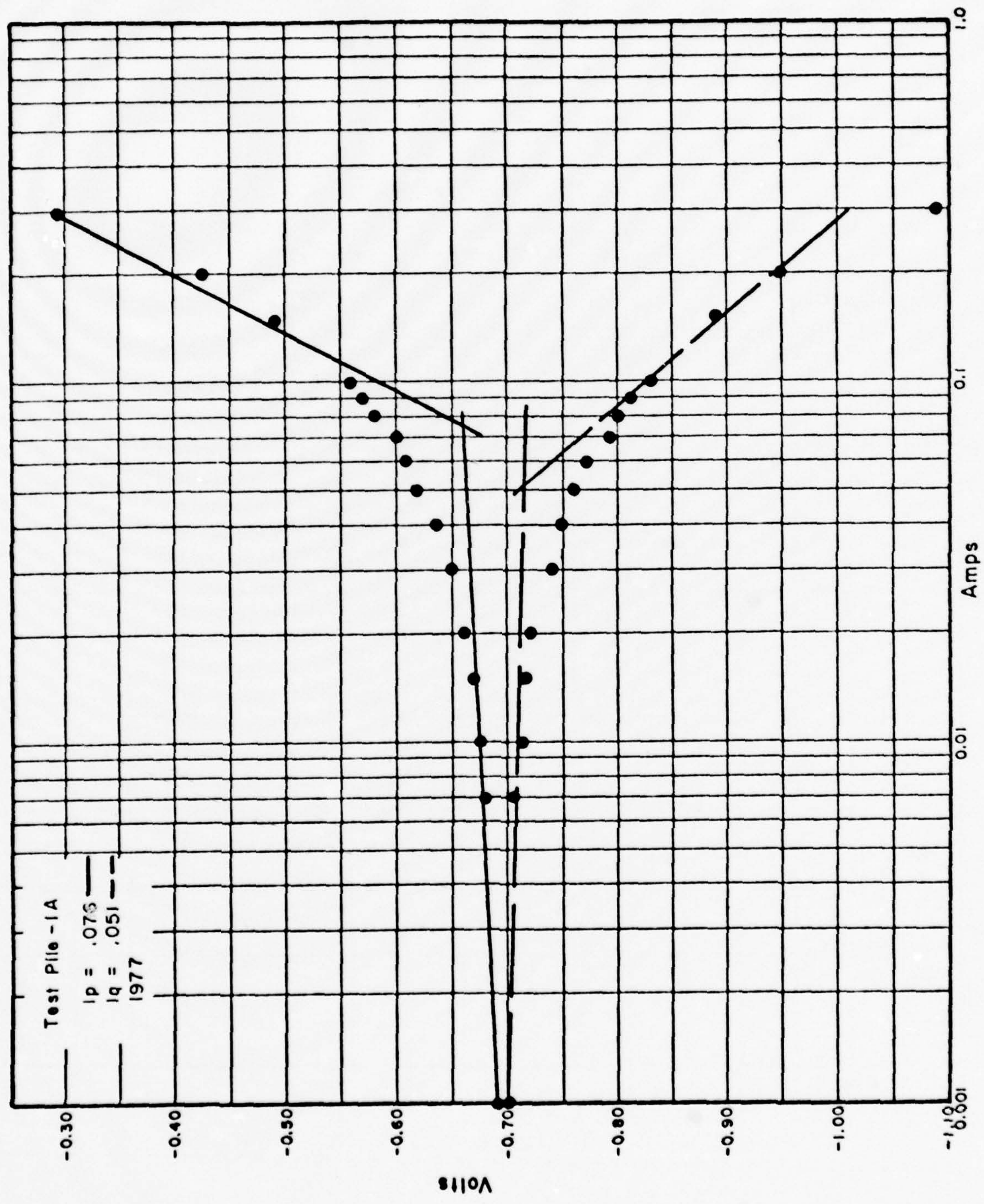
24B

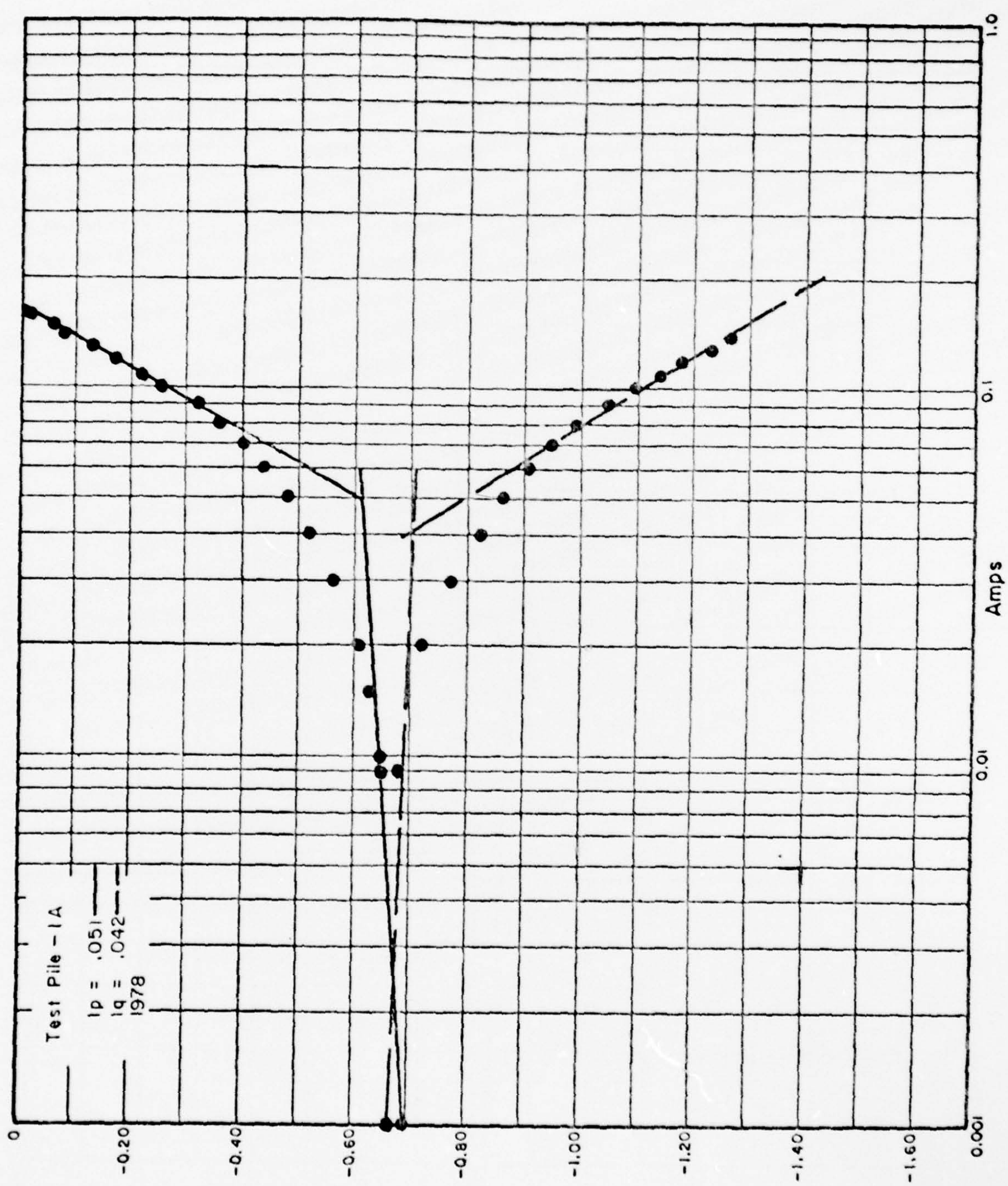
I amps	Potential volts CATH	ANODIC
0	.705	.68
.005	.715	.675
.010	.725	—
.015	.735	.65
.02	.745	—
.03	.77	.61
.035	.785	—
.04	.8	.58
.05	.83	—
.06	.855	.52
.07	.885	—
.08	.91	.45
.09	.935	—
.10	.965	.41
.12	—	.365
.14	—	.32
.15	1.12	—
.17	—	.25
.18	—	.22
.20	1.22	.17
.25	—	.12
.30	—	.05

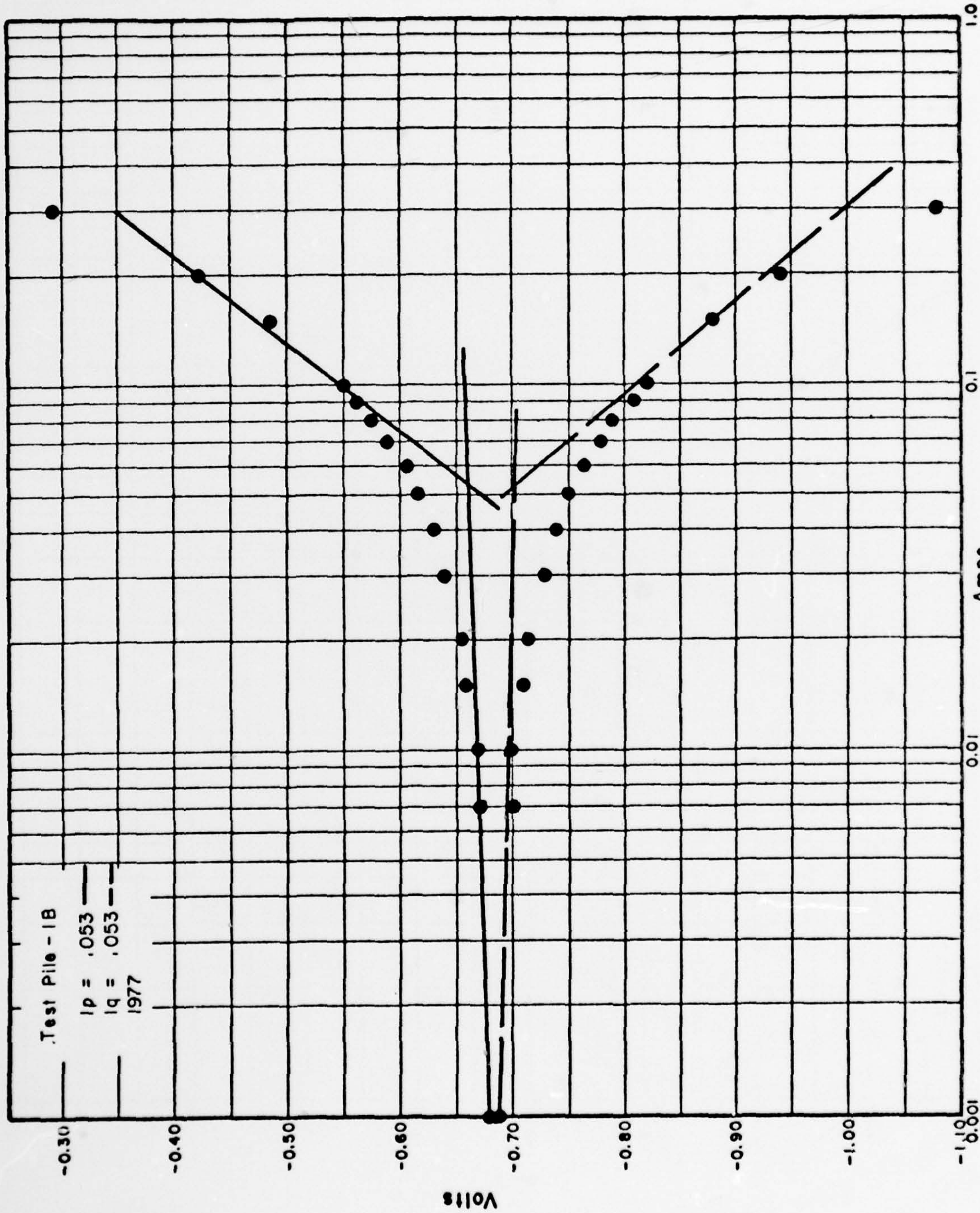
25A

I amps	Potential volts CATH	ANODIC
0	.58	.57
.005	.59	.82
.006	.593	.82
.007	.599	.83
.0075	.606	—
.008	.609	.84
.009	.612	.855
.010	.615	.87
.011	—	.88
.012	.620	.89
.013	—	.90
.014	.622	.91
.015	—	.92
.016	.628	.93
.017	—	.945
.018	.631	.955
.019	—	.97
.020	.639	.99
.030	.658	—
.040	.670	—
.050	.689	—
.060	.708	—
.080	.763	—

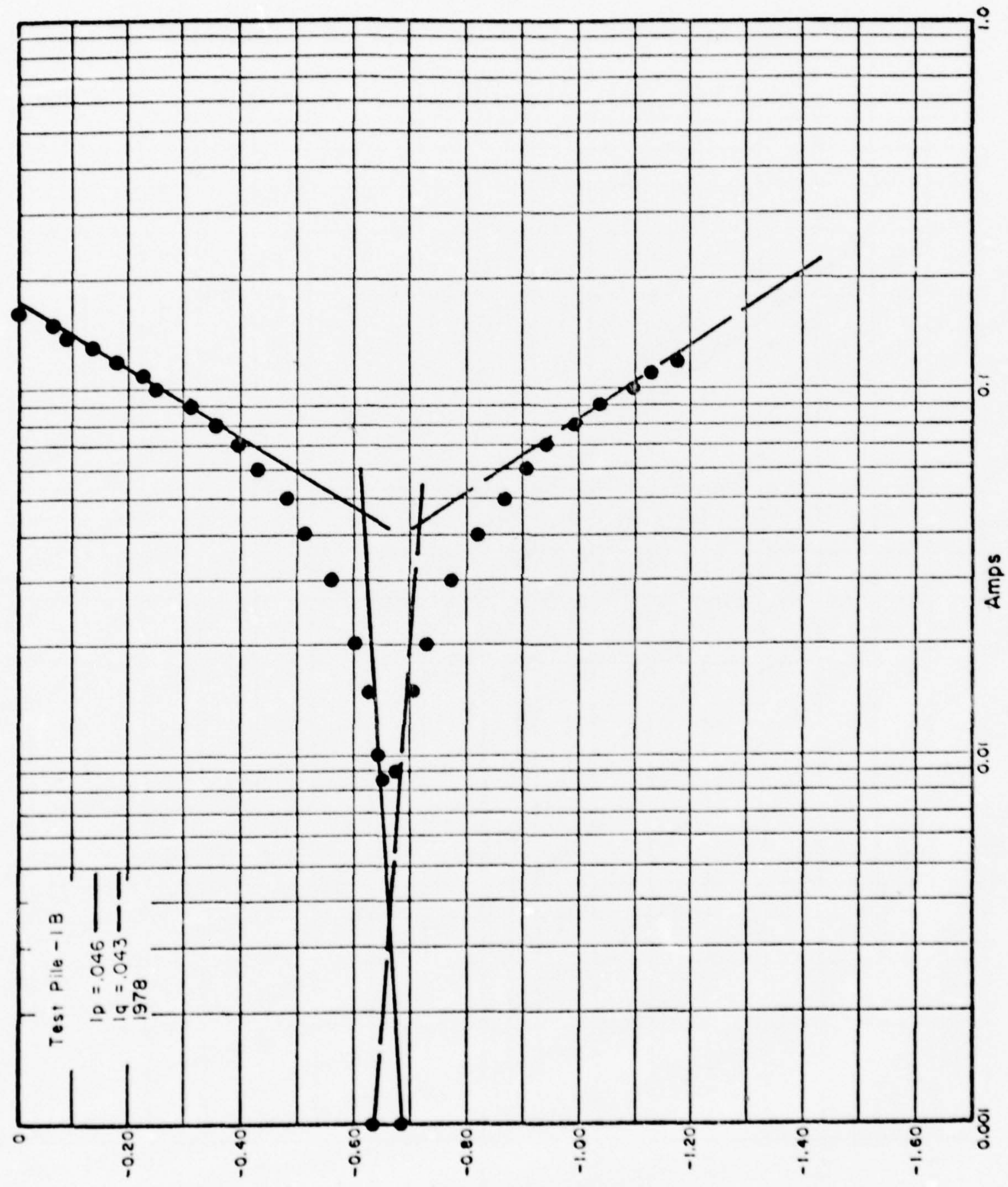
TAFEL EXTRAPOLATIONS

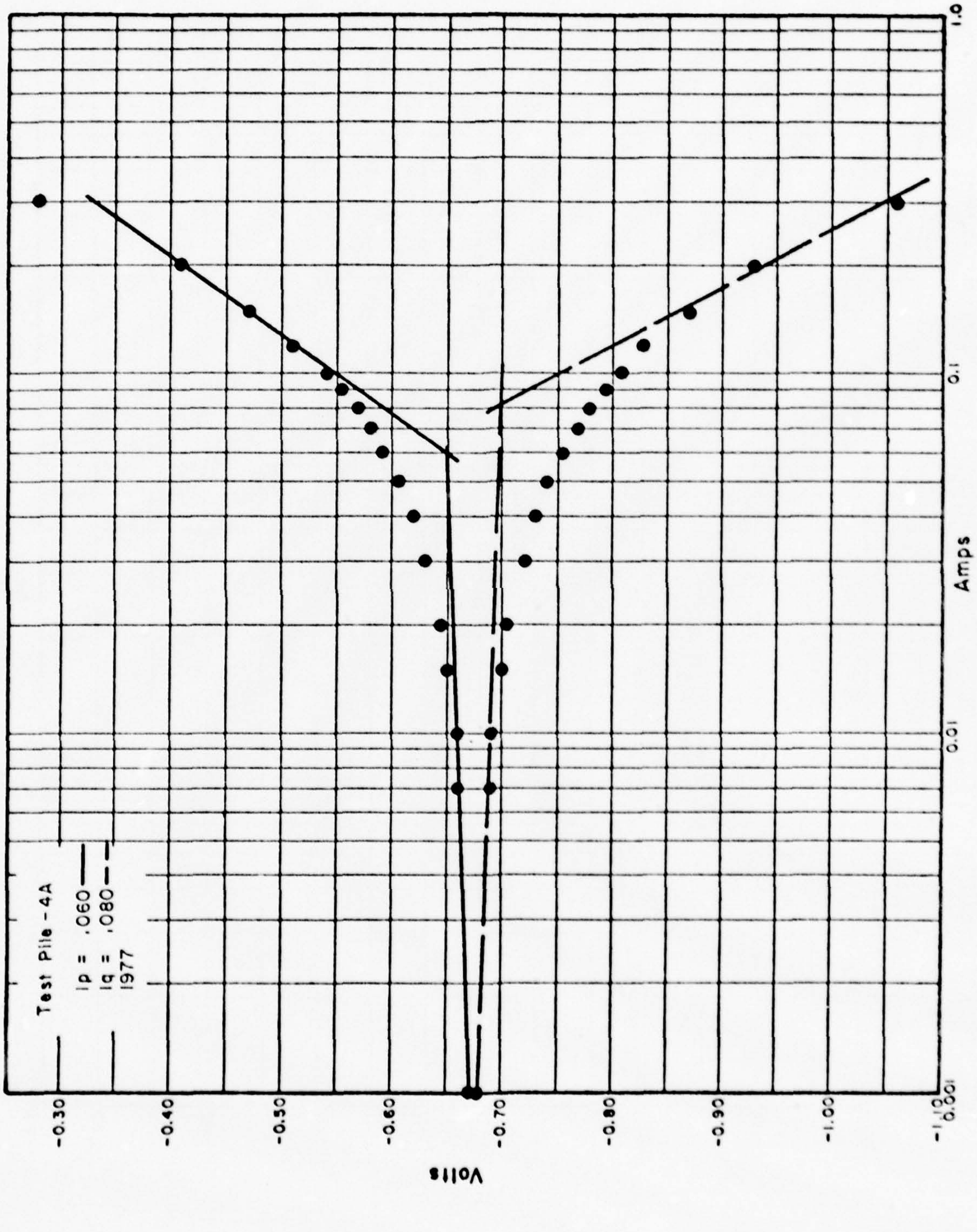


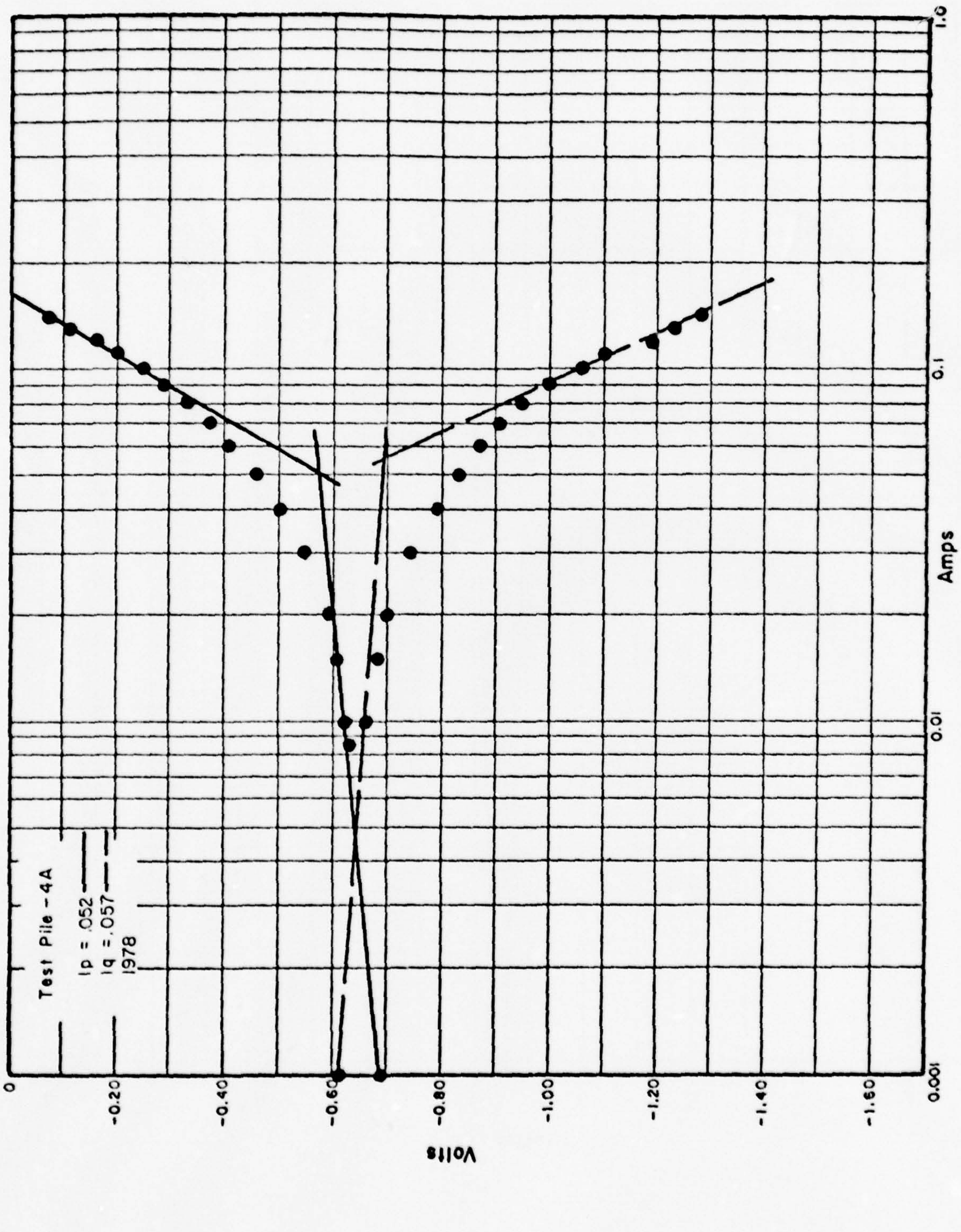

Test Pile - 1A
Ip = .051
Iq = .042
1978
Volts
Amps
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

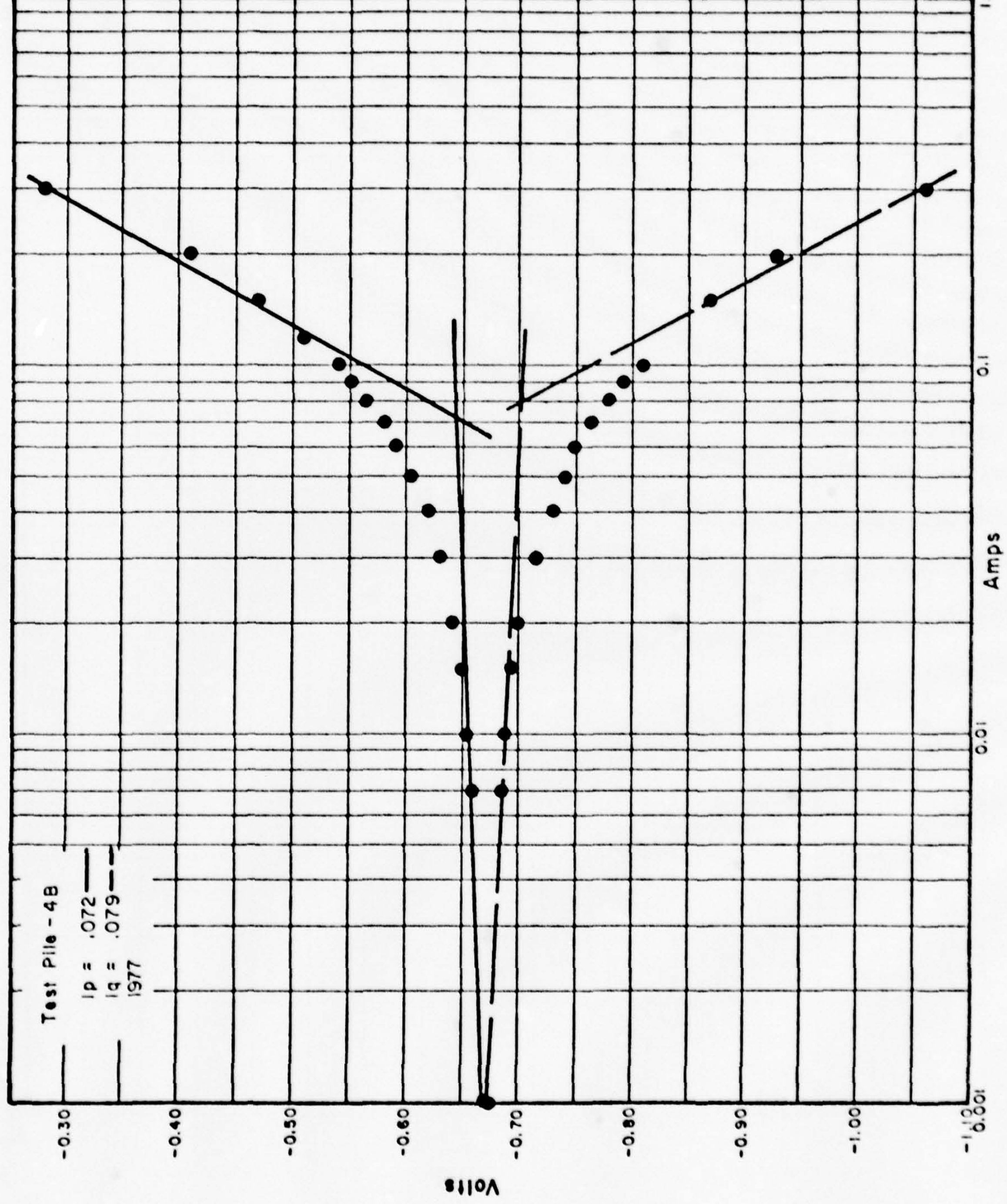


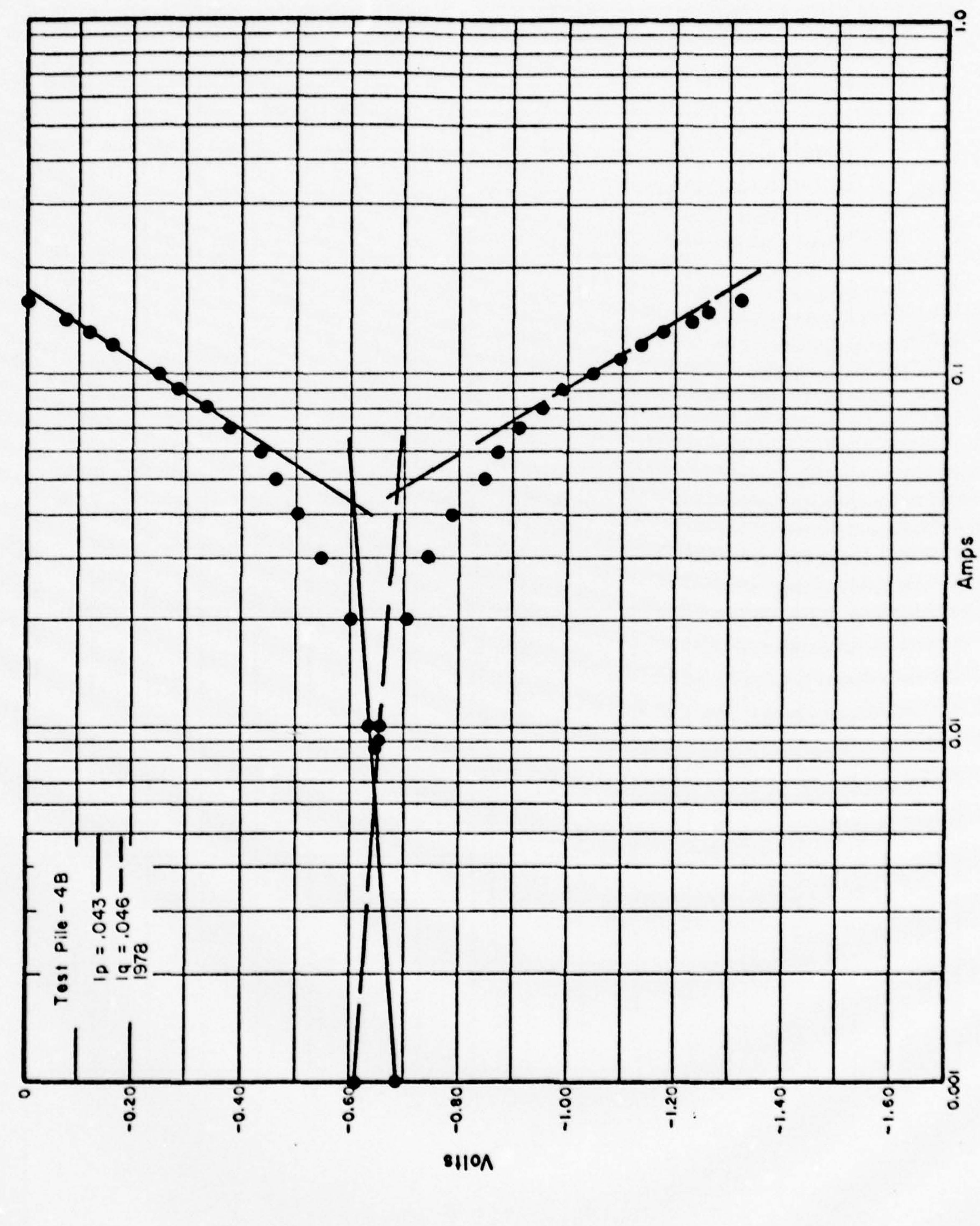
Test Pile - 1B
Ip = .053
Iq = .053
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0

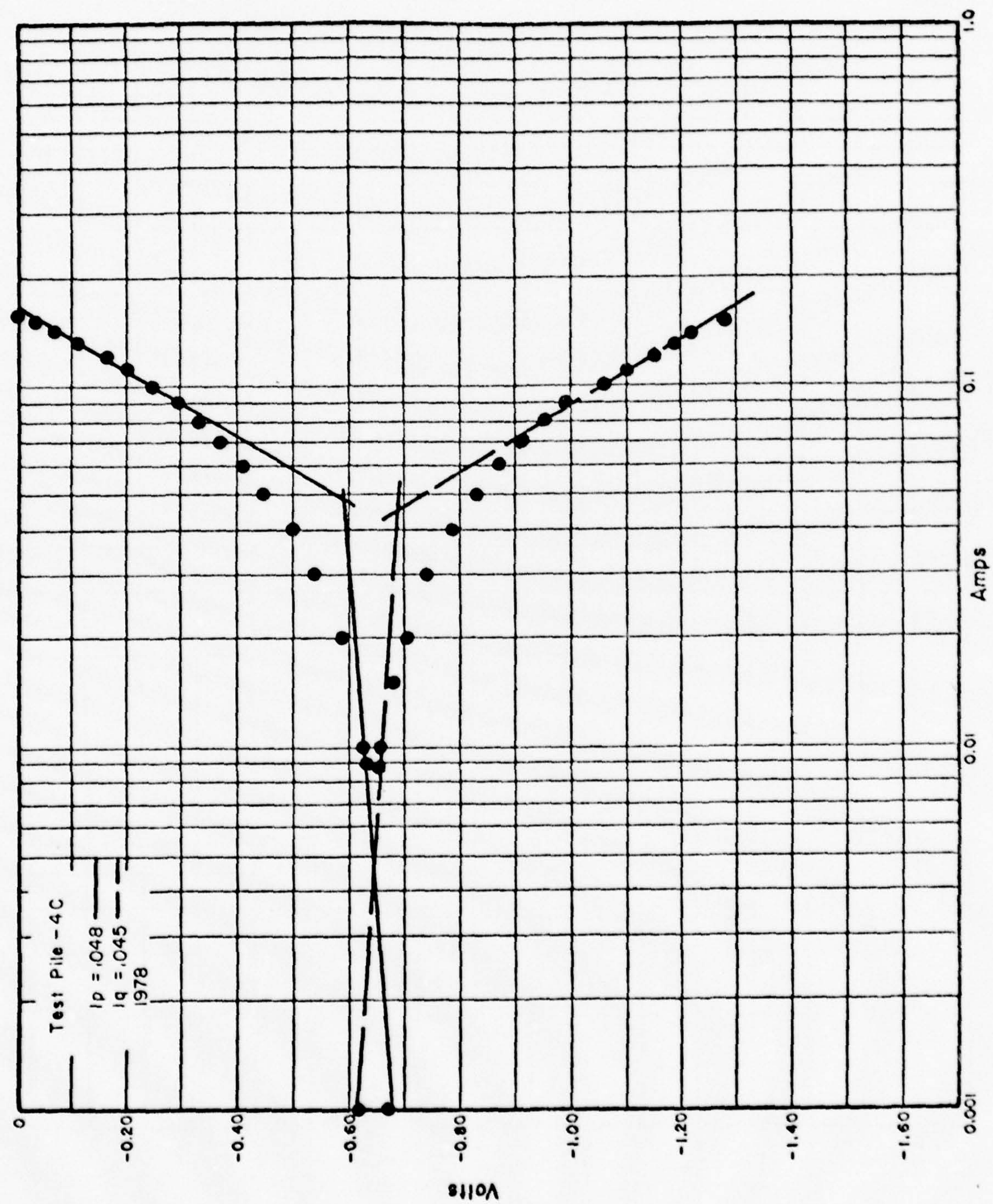

Test Pile - 1B
Ip = .046
Iq = .043
1978
Amps
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0


Test Pile - 4A
Ip = .060
Iq = .080
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0

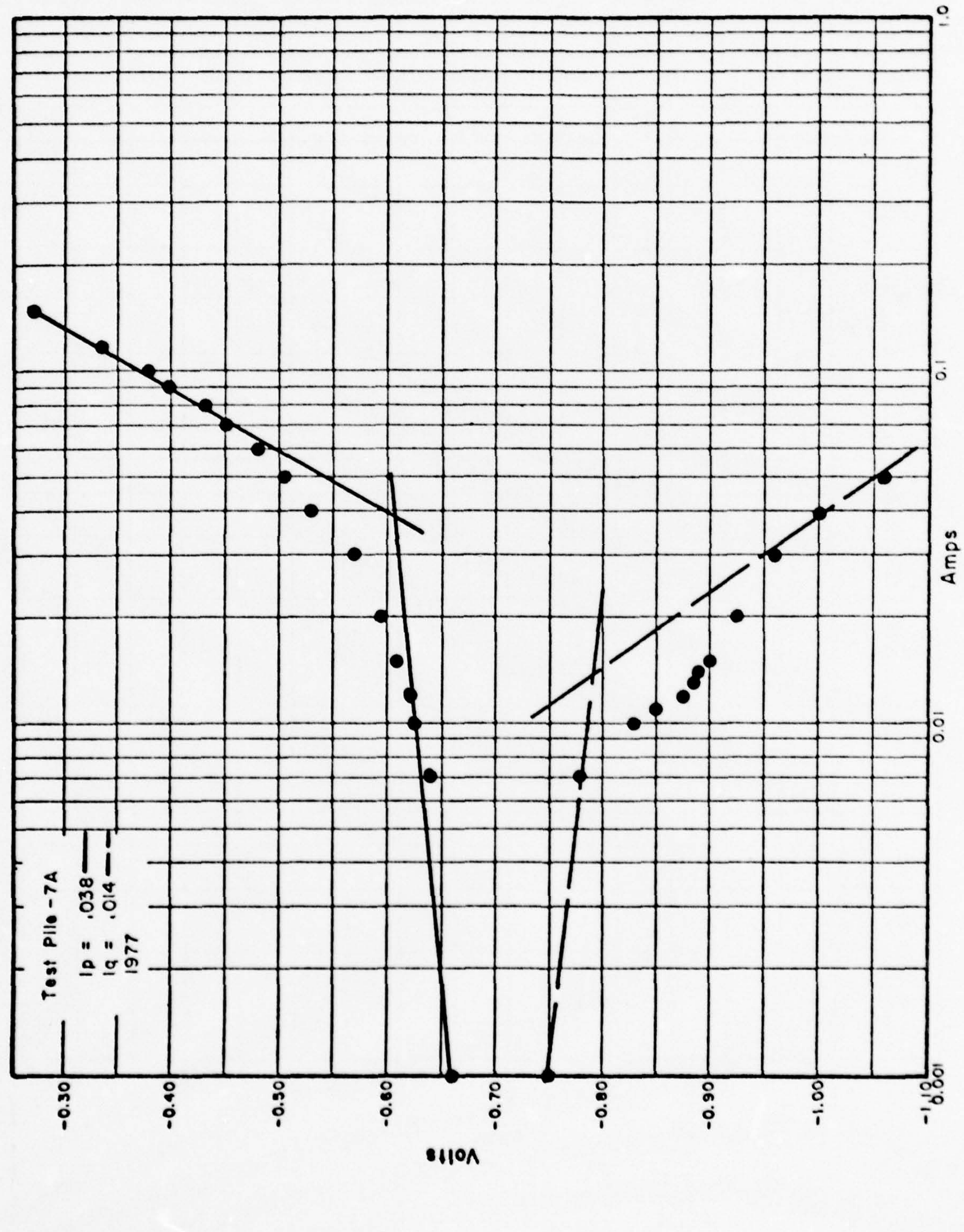

Test Pile - 4A
Ip = .052
Iq = .057
1978
Amps
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

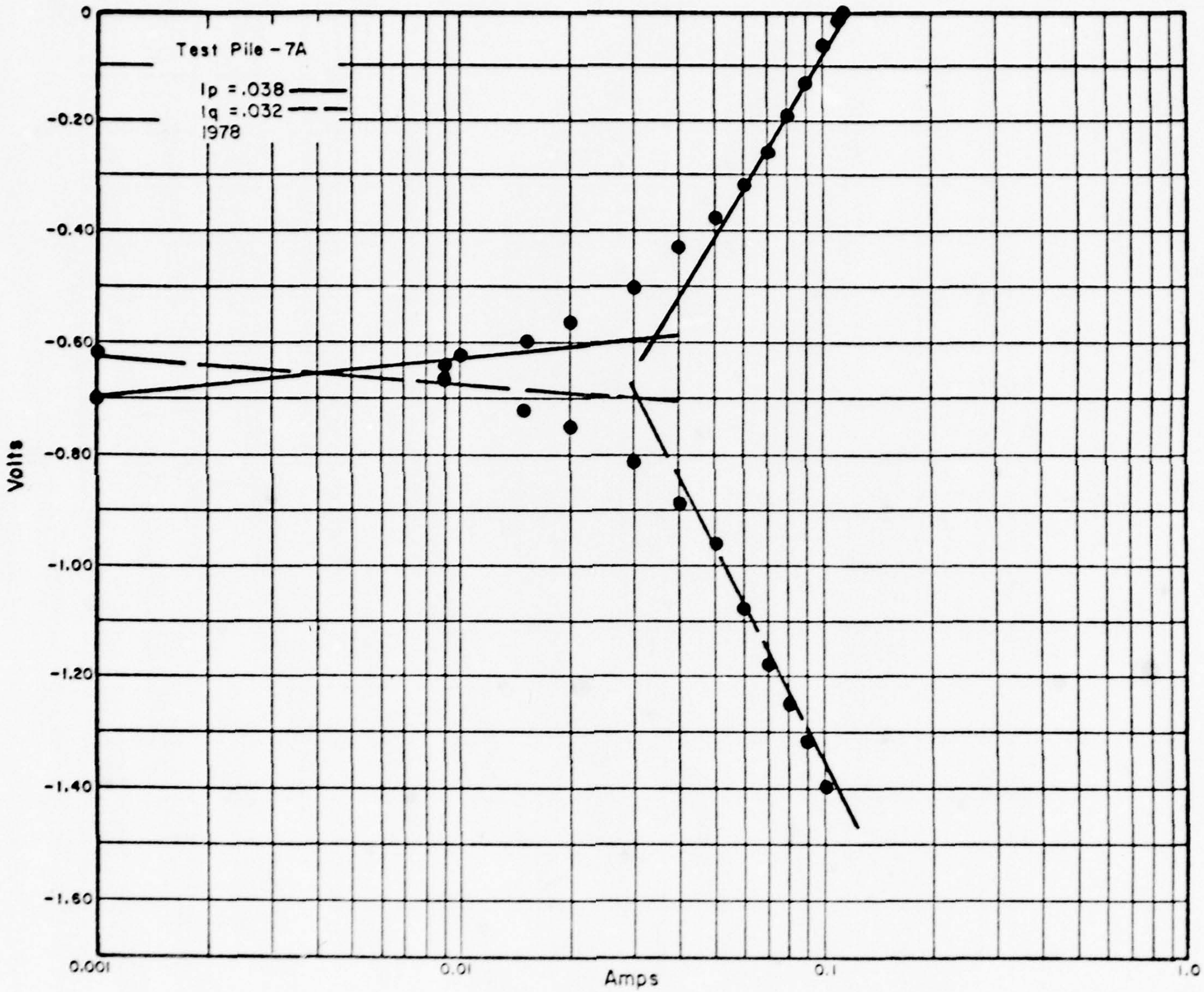

Test Pile - 4B
Ip = .072
Iq = .079
1977
Amps
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0


Test Pile - 4B
Ip = .043
Iq = .046
1978
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Volts
0.001
0.01
0.1
1.0
Amps

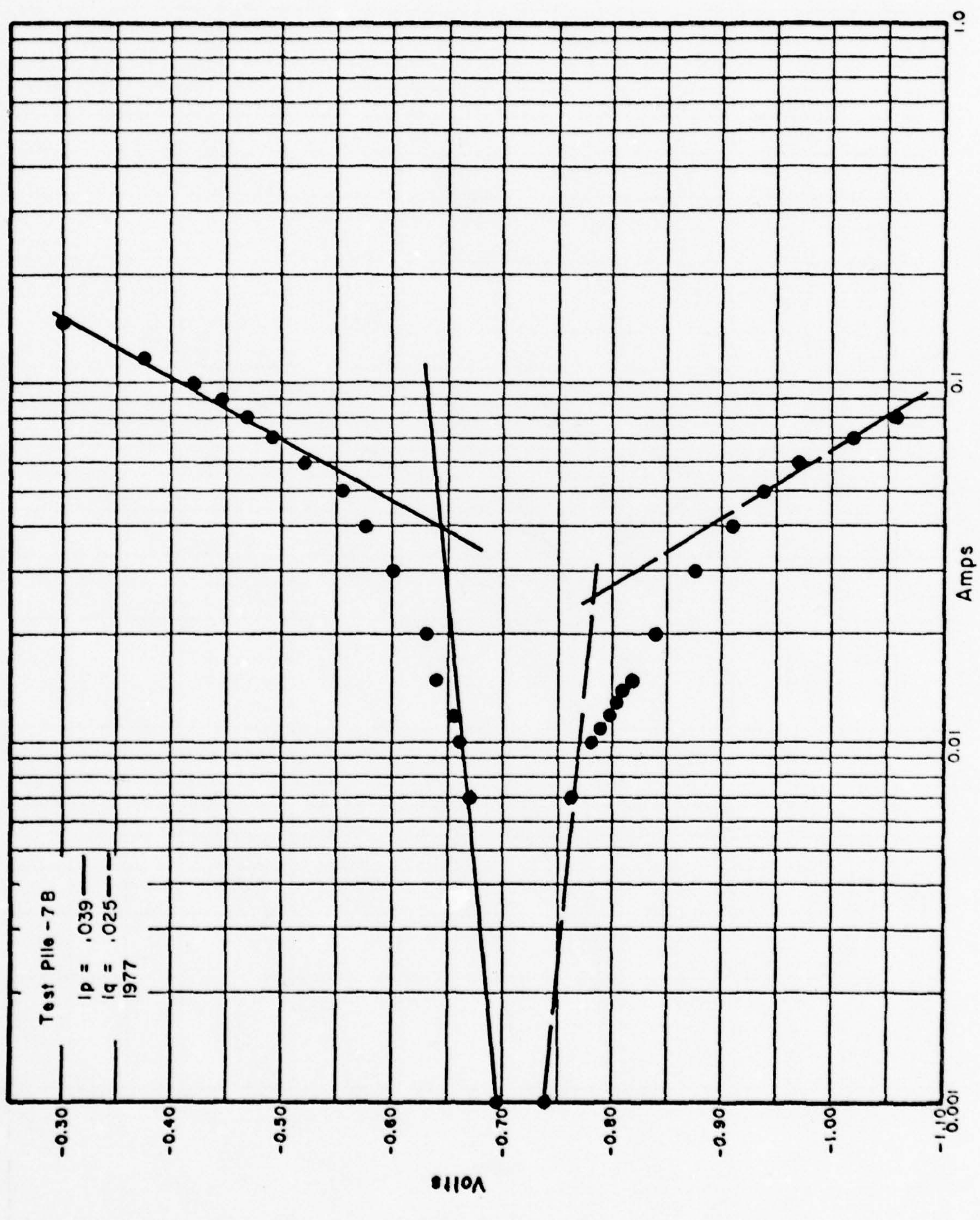


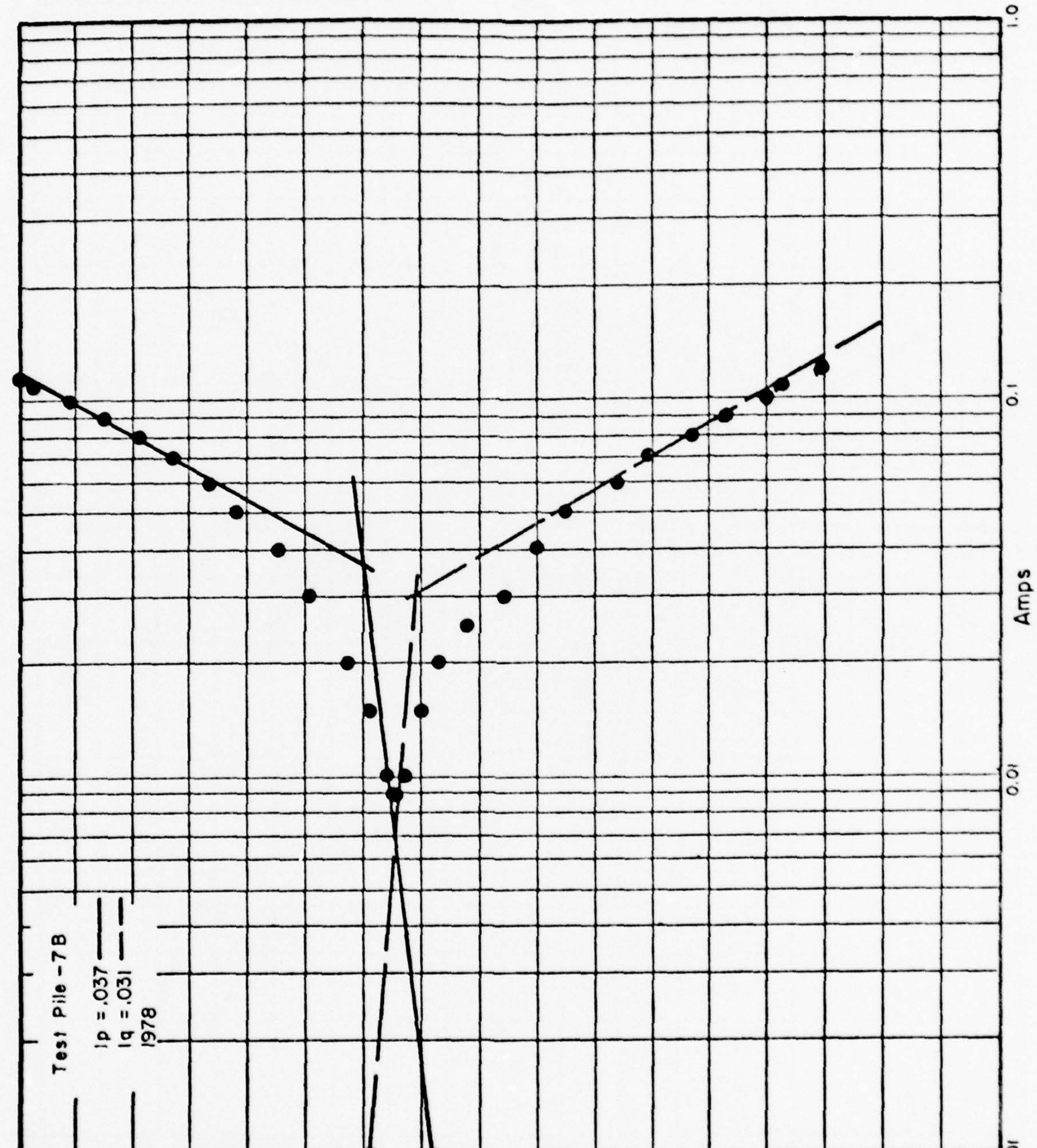
Test Pile - 4C
Ip = .048
Iq = .045
1978
Amps
Volts
0.001
0.01
0.1
1.0
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60


Test Pile -7A
Ip = .038
Iq = .014
1977
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Volts
0.001
0.01
0.1
1.0
Amps

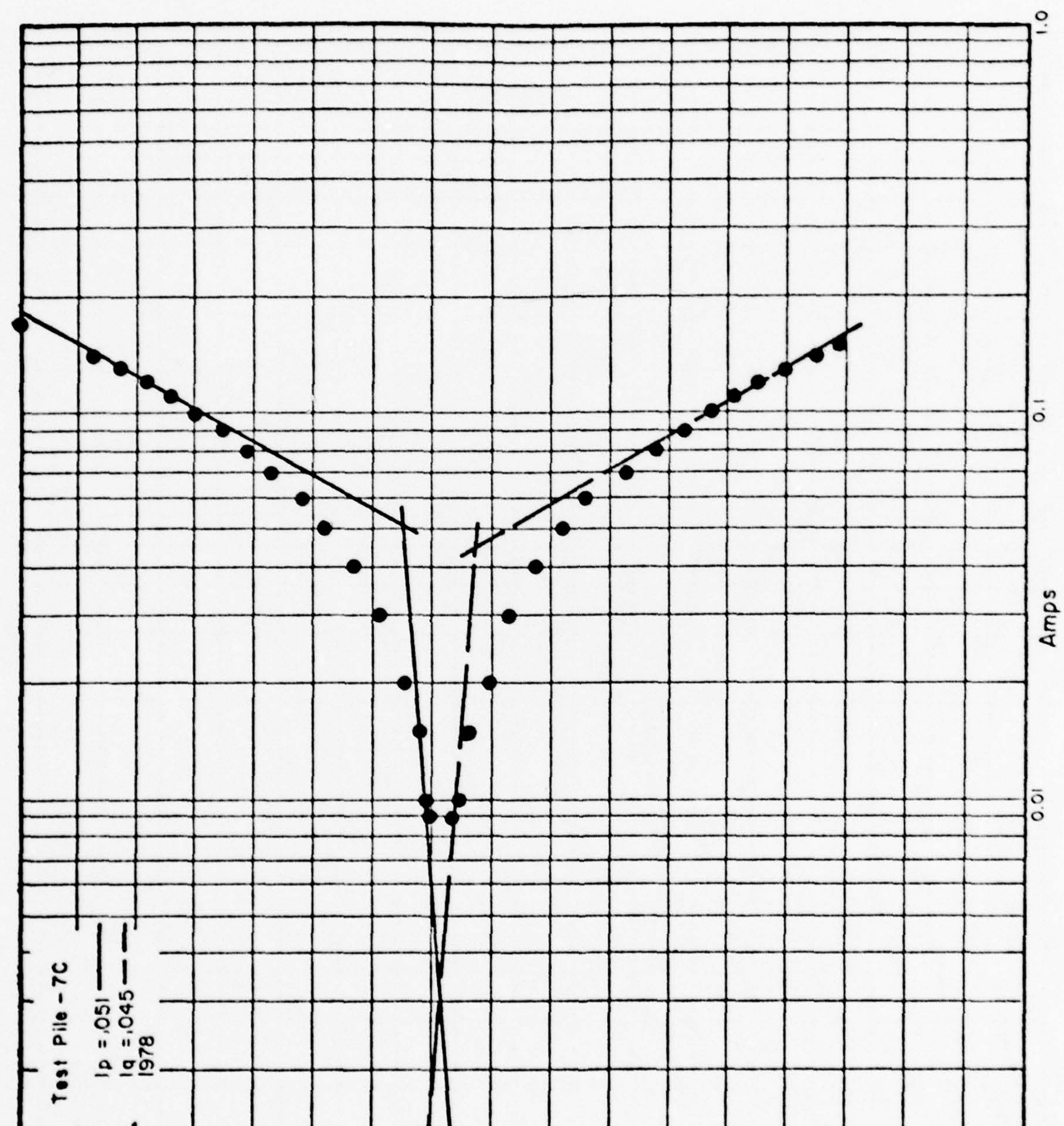


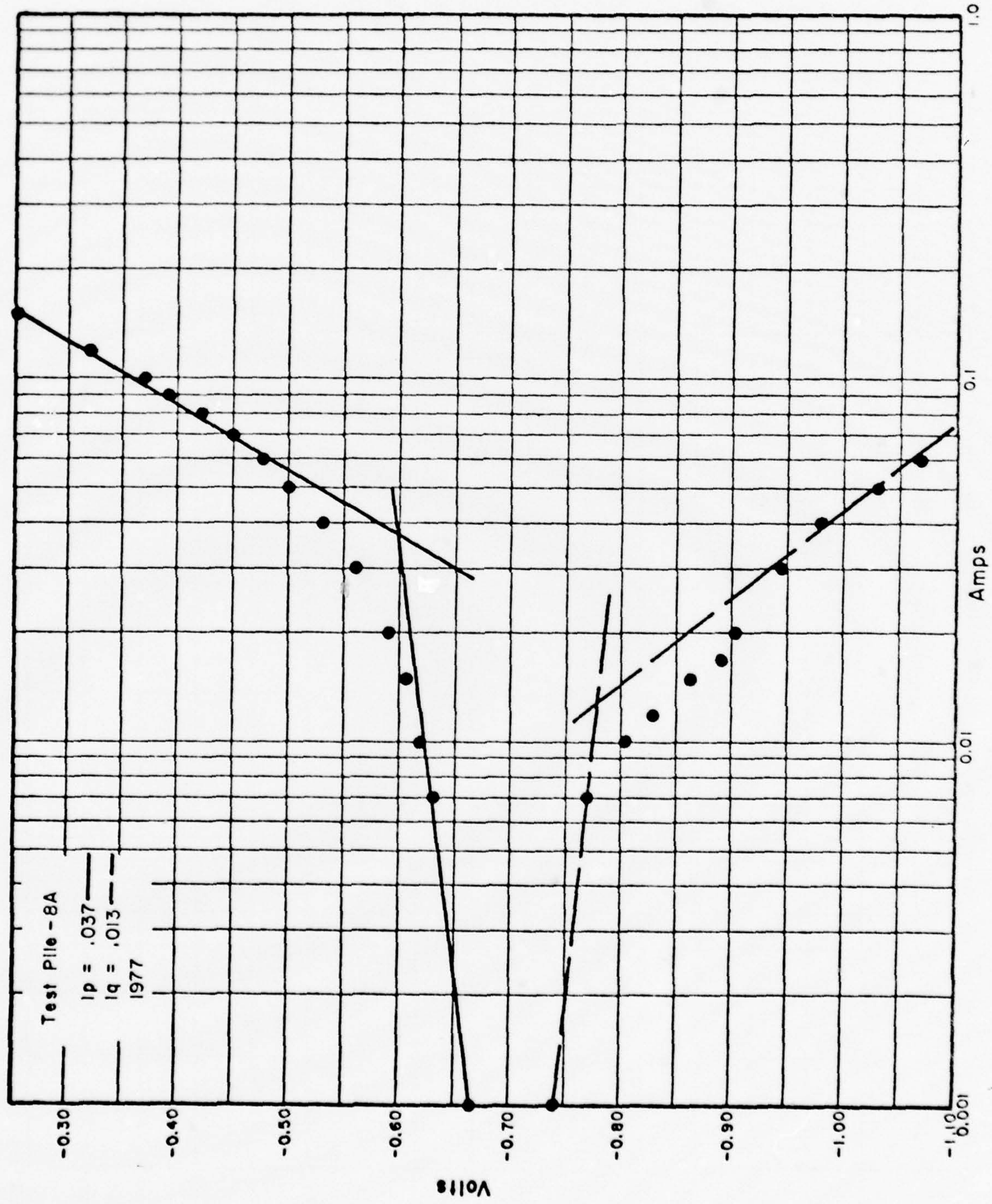
Test Pile - 7A
Ip =.038
Iq =.032
1978
Volts
Amps
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

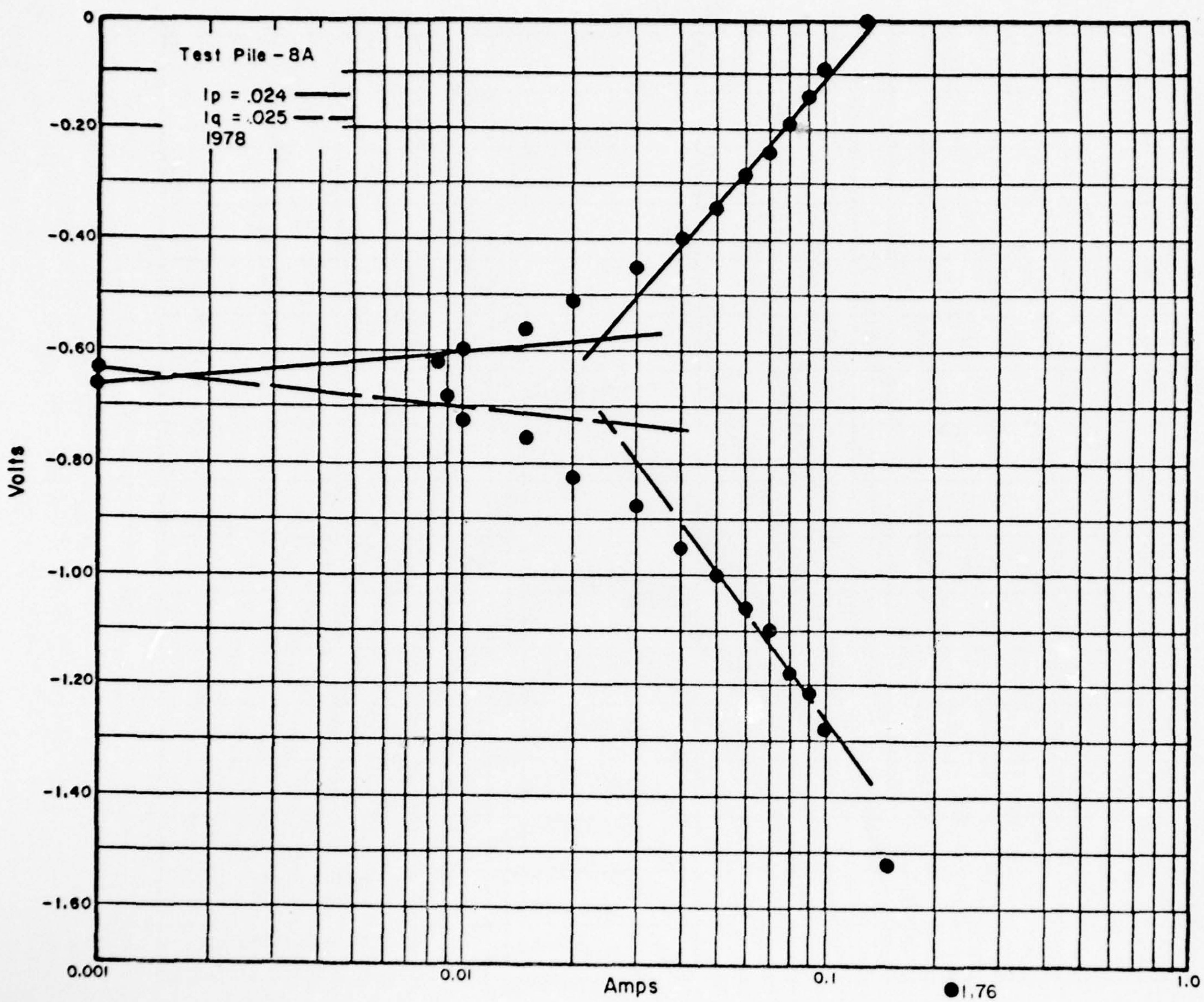

Test Pile - 7B
Ip = .039
Iq = .025
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0

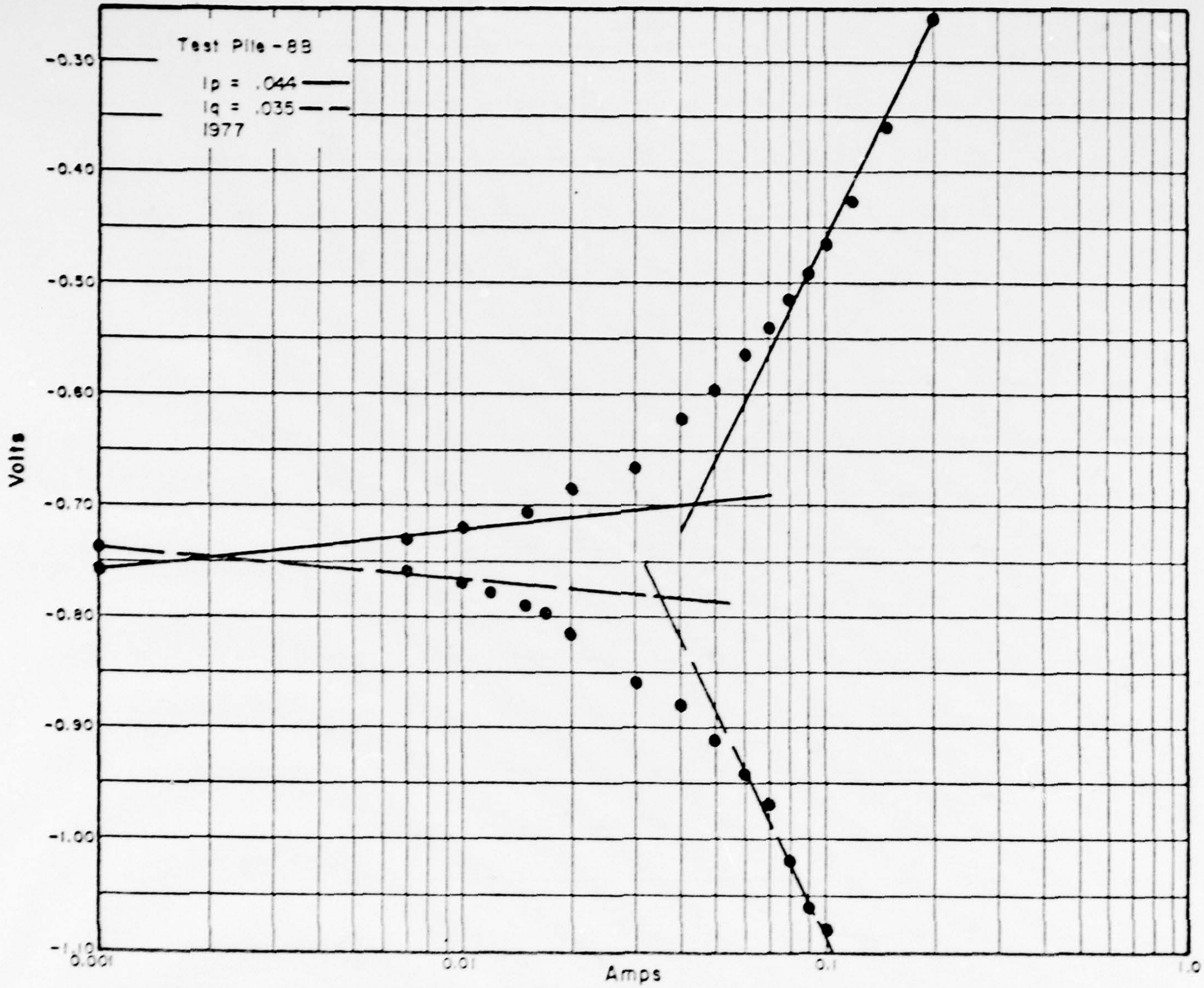


Test Pile -7B
Ip = .037
Iq = .031
1978
Amps
Volts
0.001
0.01
0.1
1.0
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60

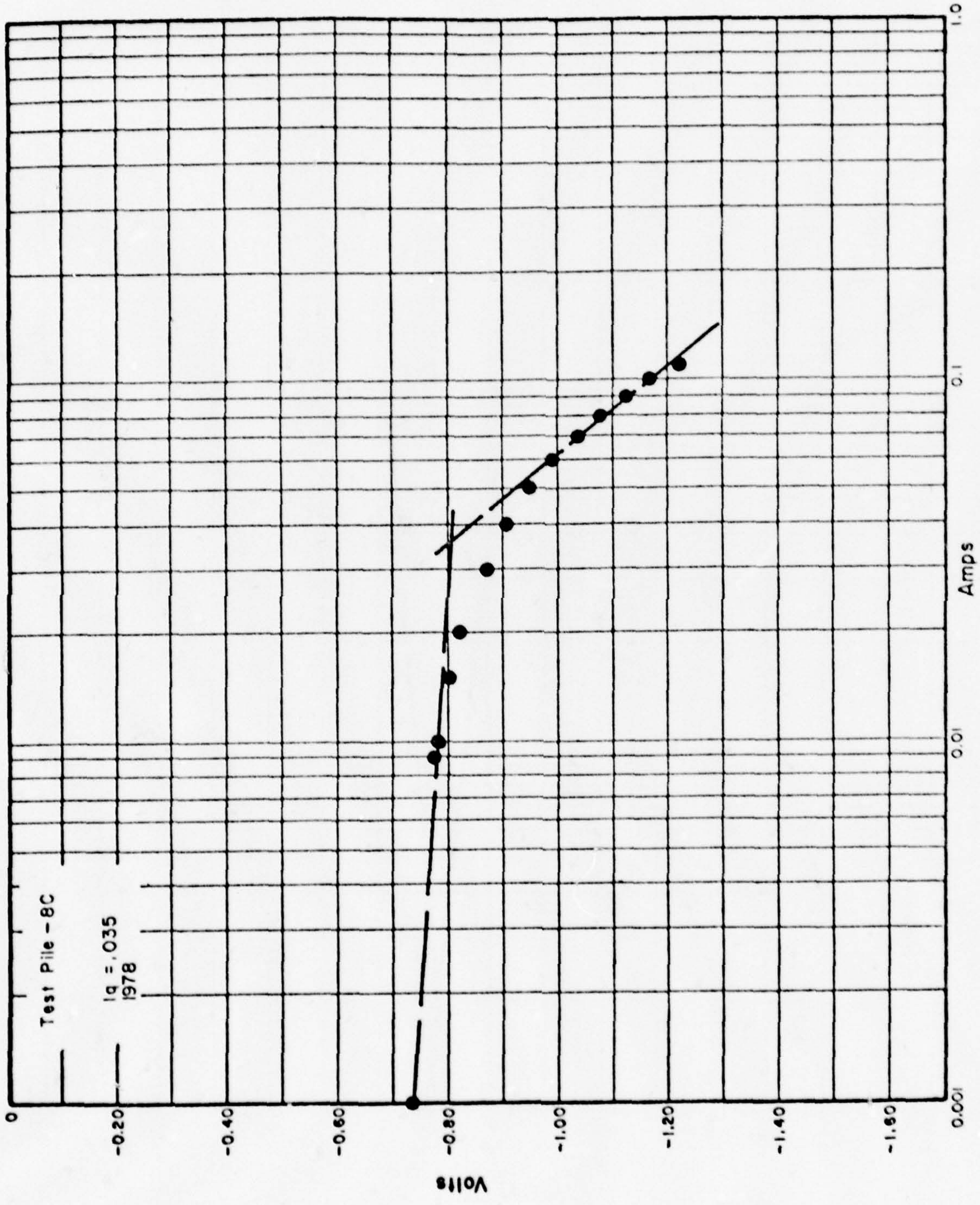

Test Pile - 7C
Ip =.051
Iq =.045
1978
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Volts
0.001
0.01
0.1
1.0
Amps

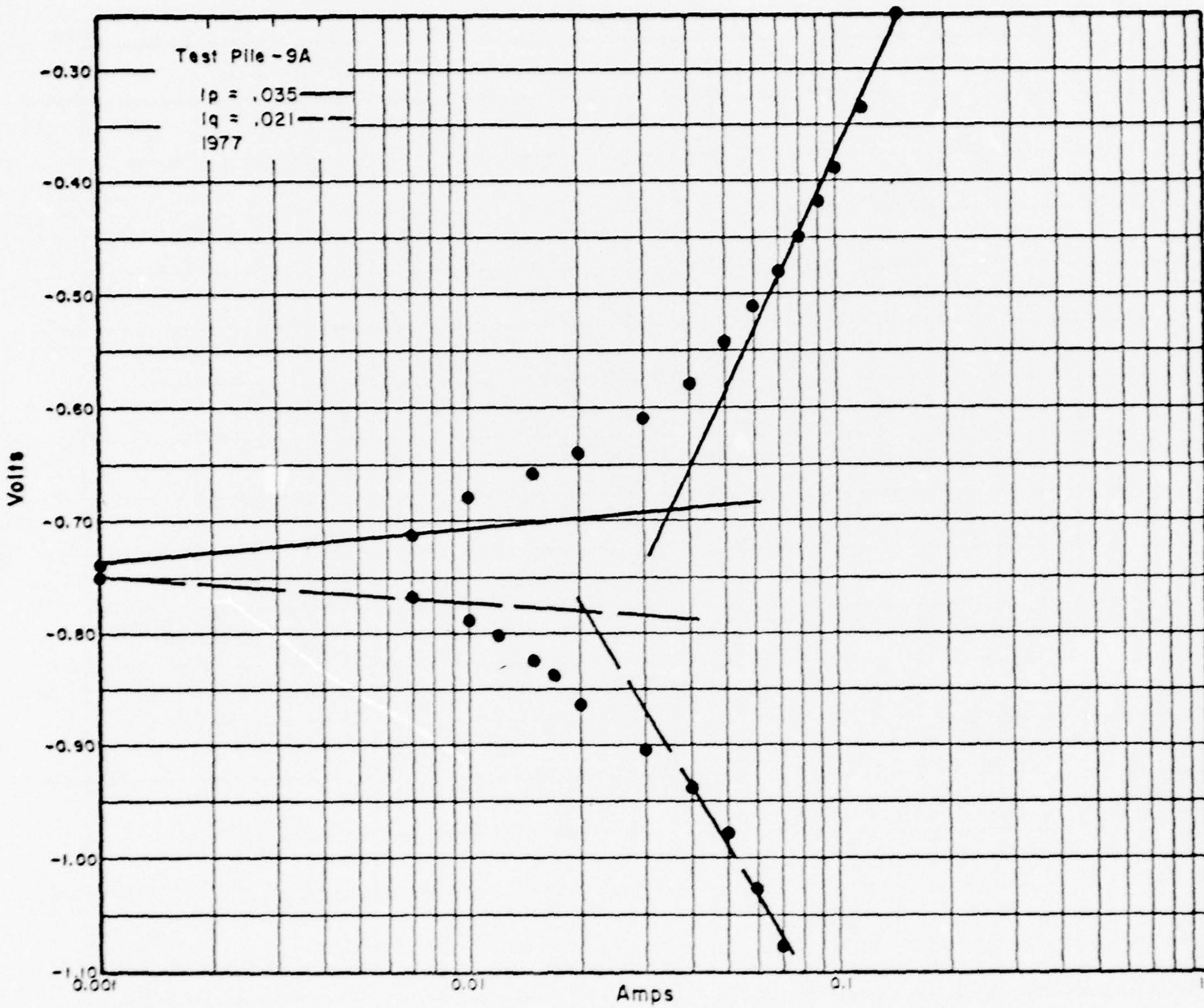

Test Pile - 8A
Ip = .037
Iq = .013
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0


Test Pile - 8A
Ip = .024
Iq = .025
1978
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0
Amps
1.76

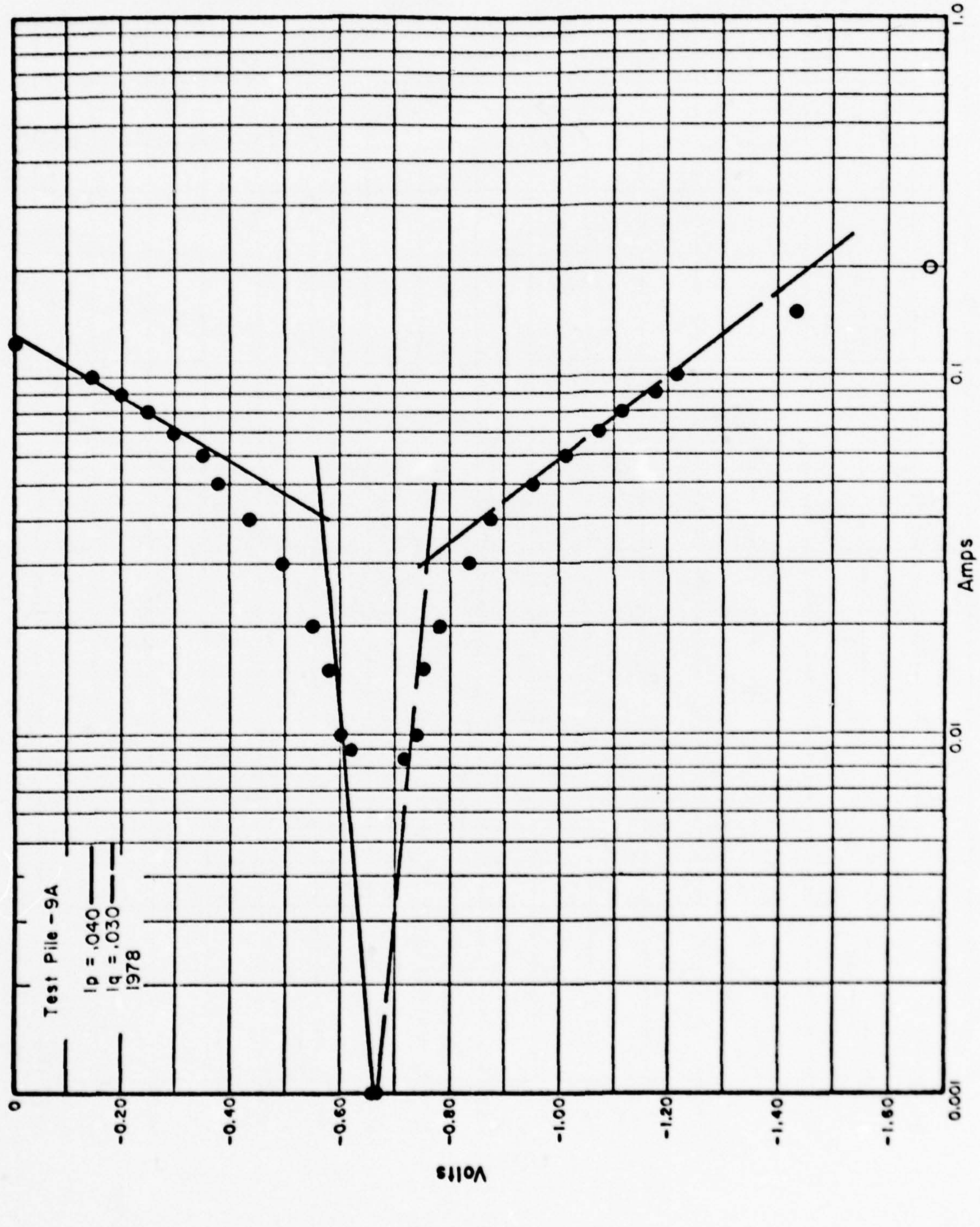


Test Pile - 88
Ip = .044
Iq = .035
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0

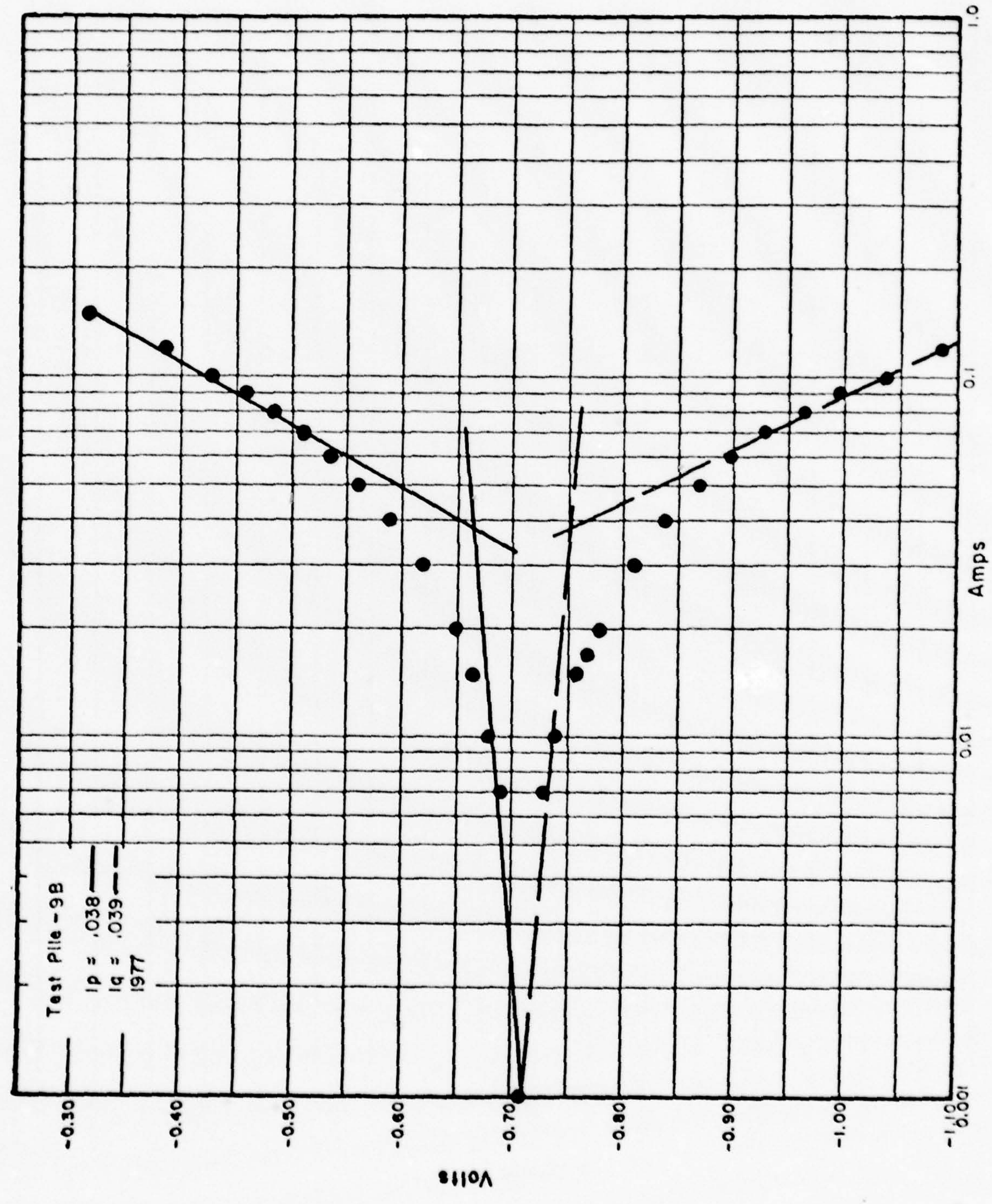

Test Pile - 8C
Iq = .035
1978
Amps
Volts
0.001
0.01
0.1
1.0
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60

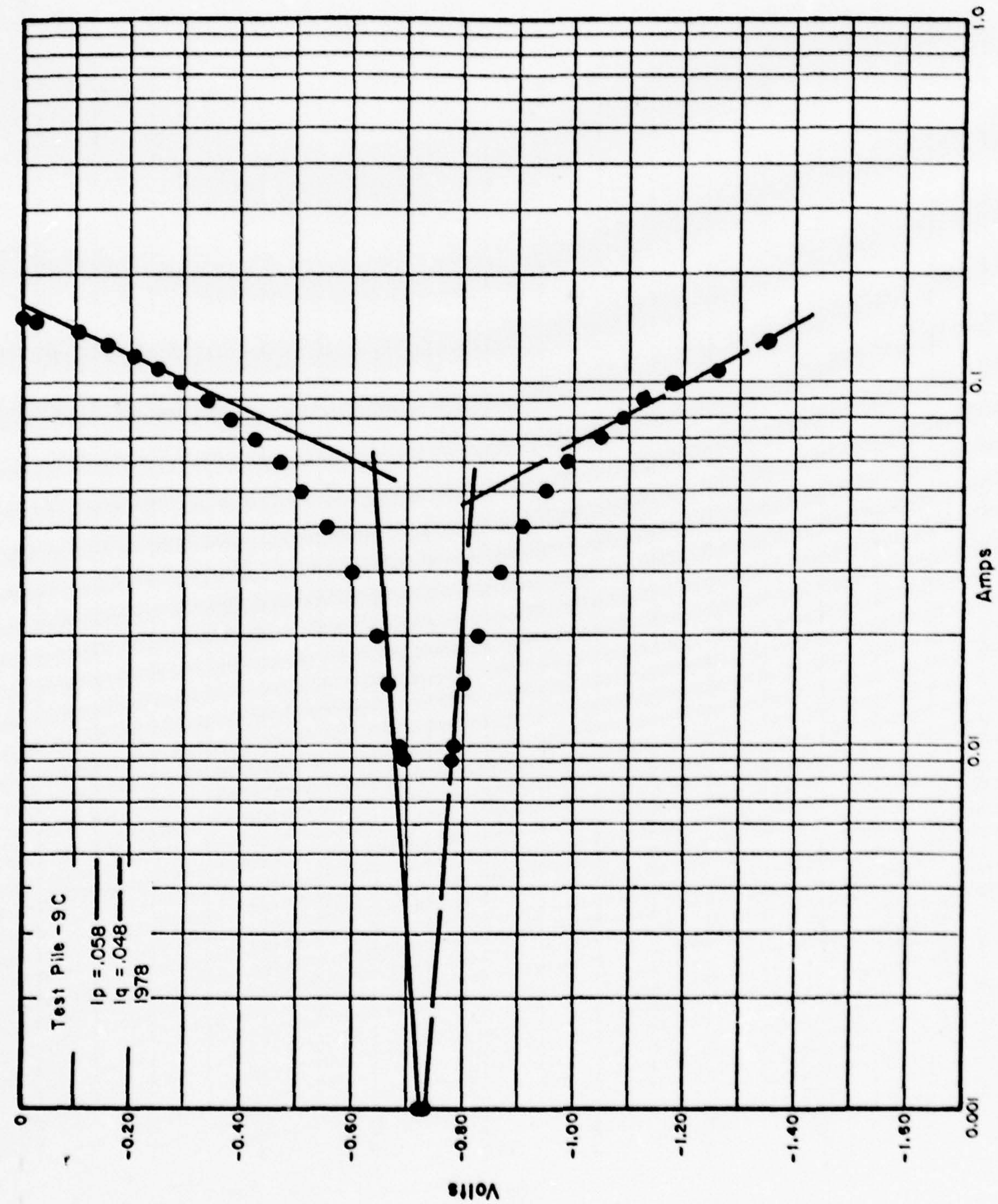


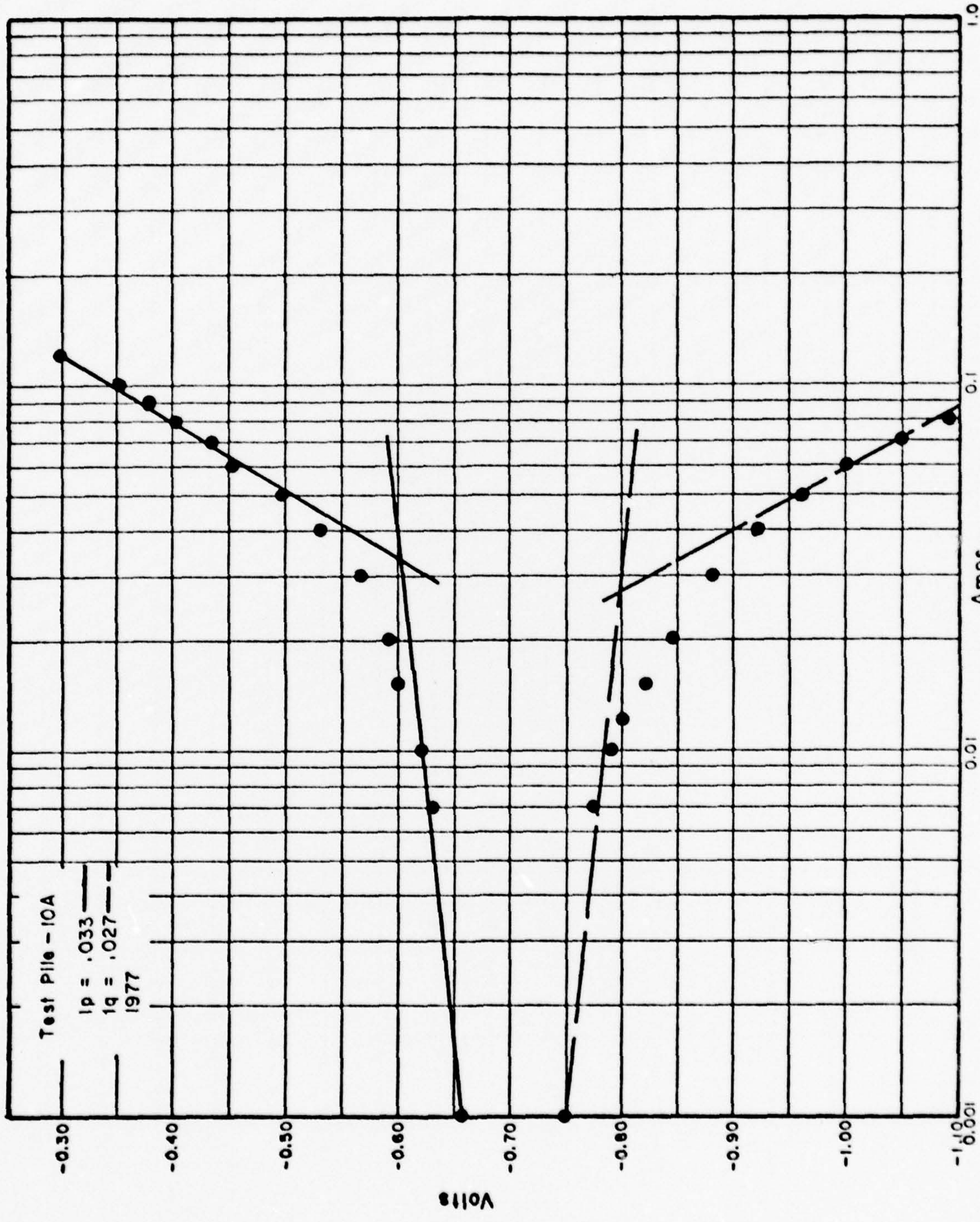
Test Pile - 9A
Ip = .035
Iq = .021
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0



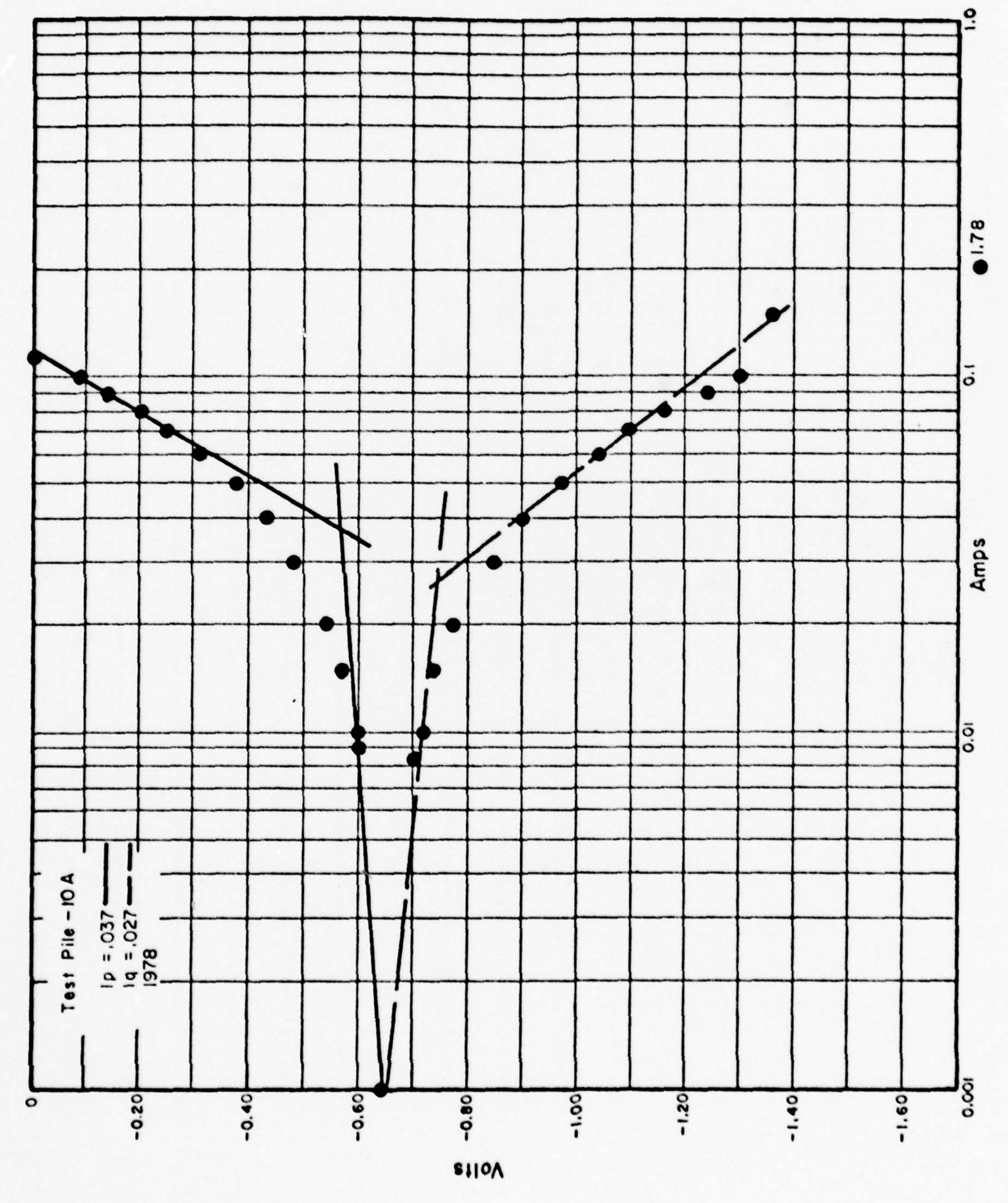
Test Pile - 9A
Ip = .040
Iq = .030
1978
Volts
Amps
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

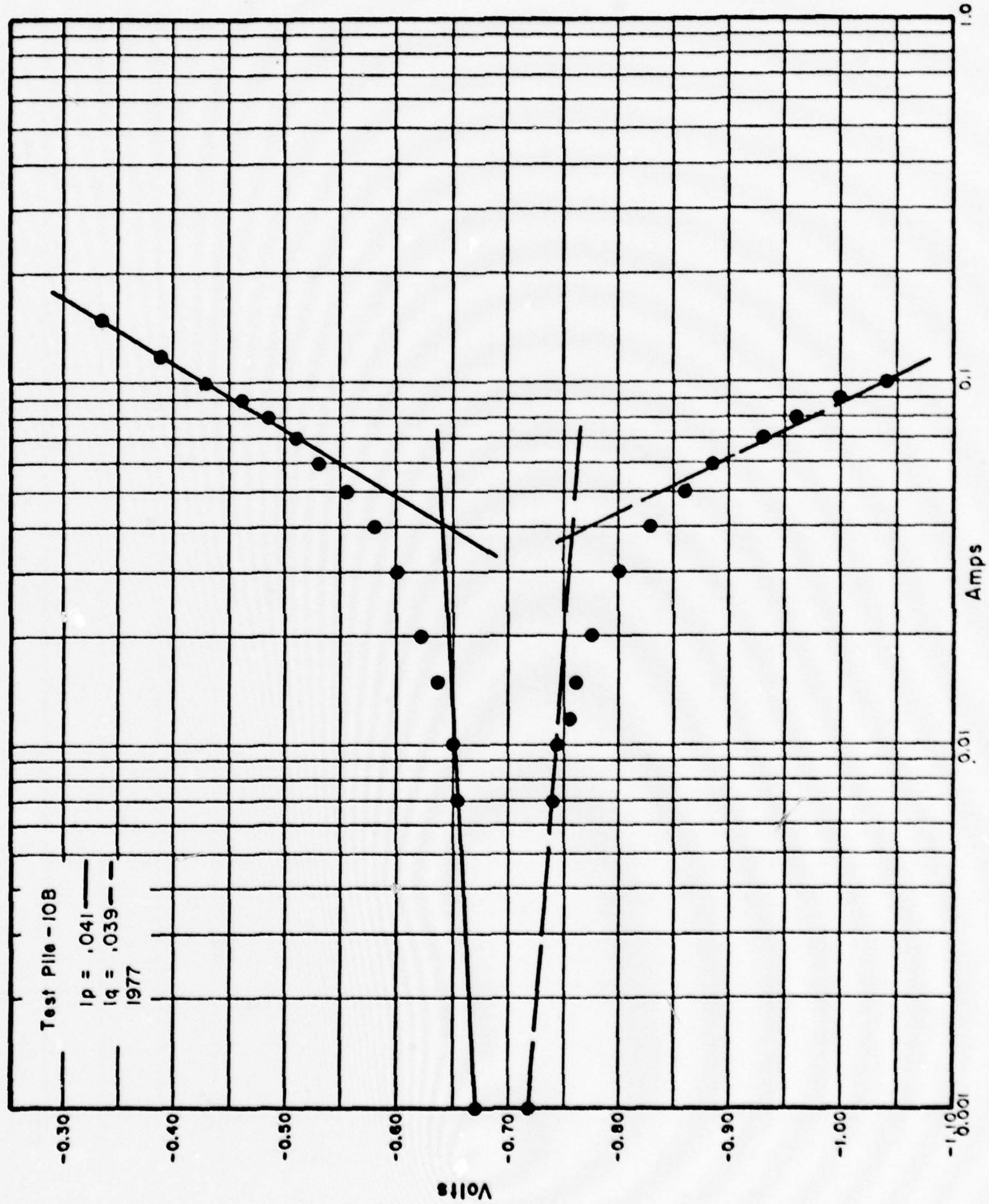

Test Pile - 9B
Ip = .038
Iq = .039
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0

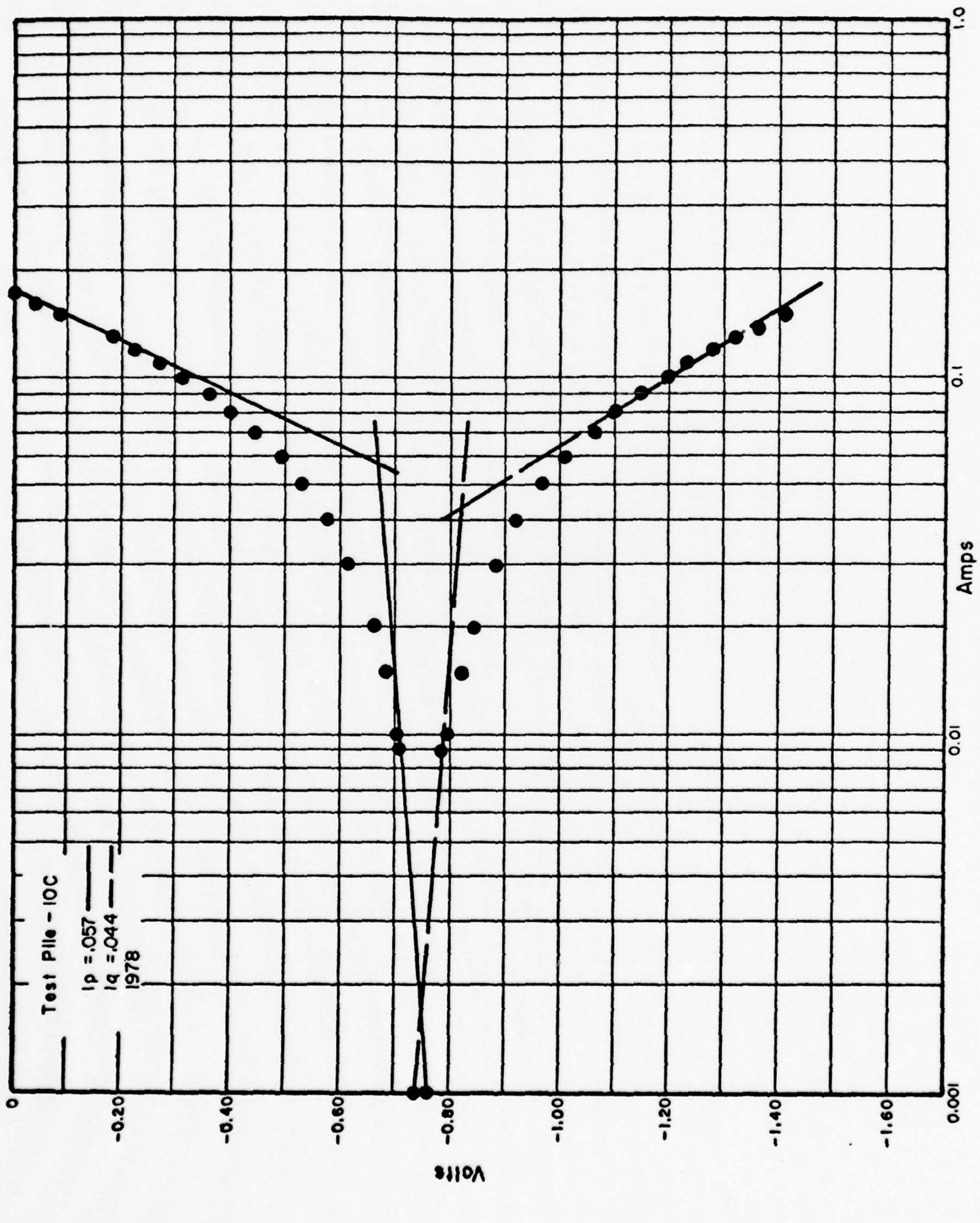

Test Pile - 9C
Ip = .058
Iq = .048
1978
Amps
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

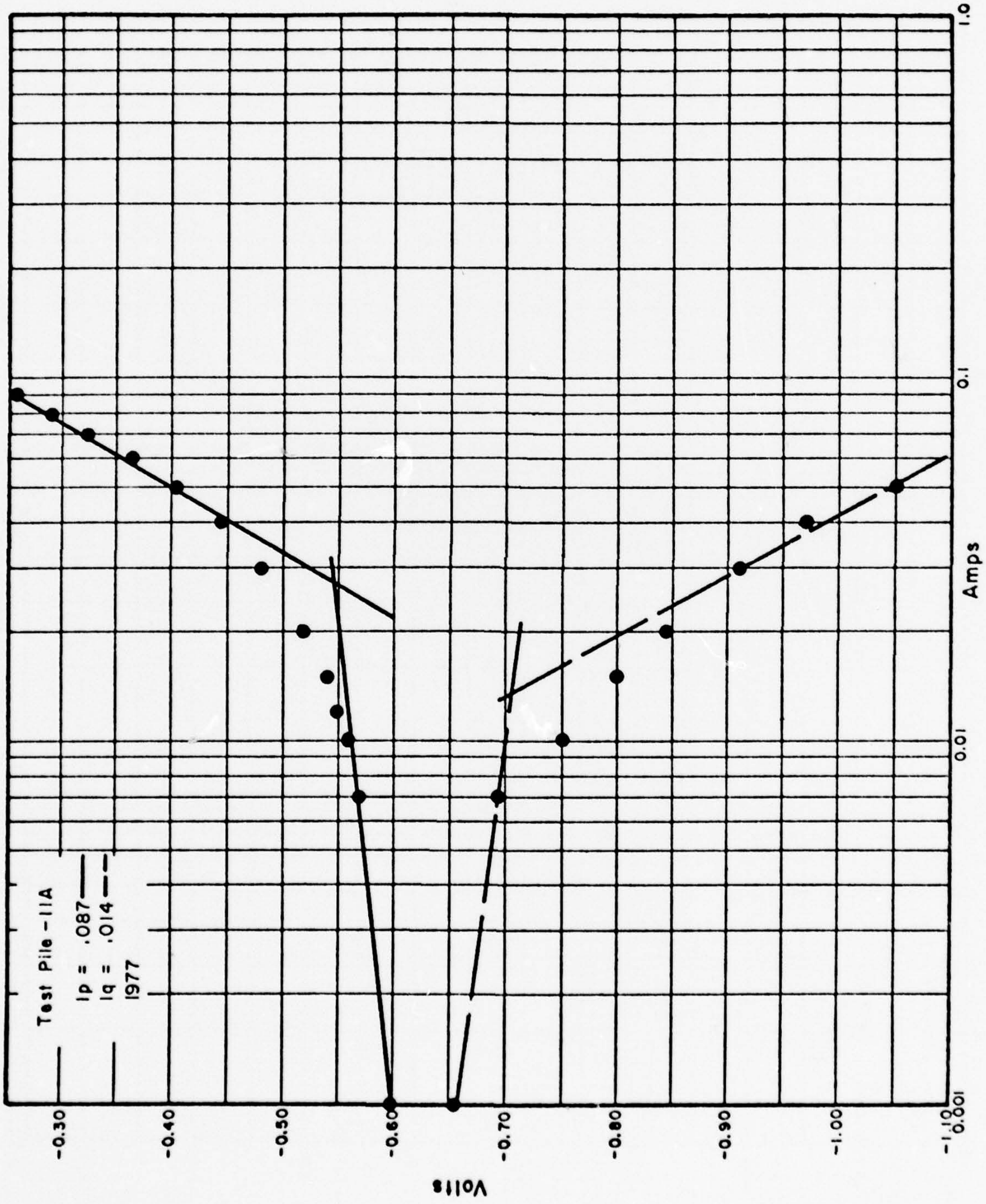


Test Pile - 10A
Ip = .033
Iq = .027
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0

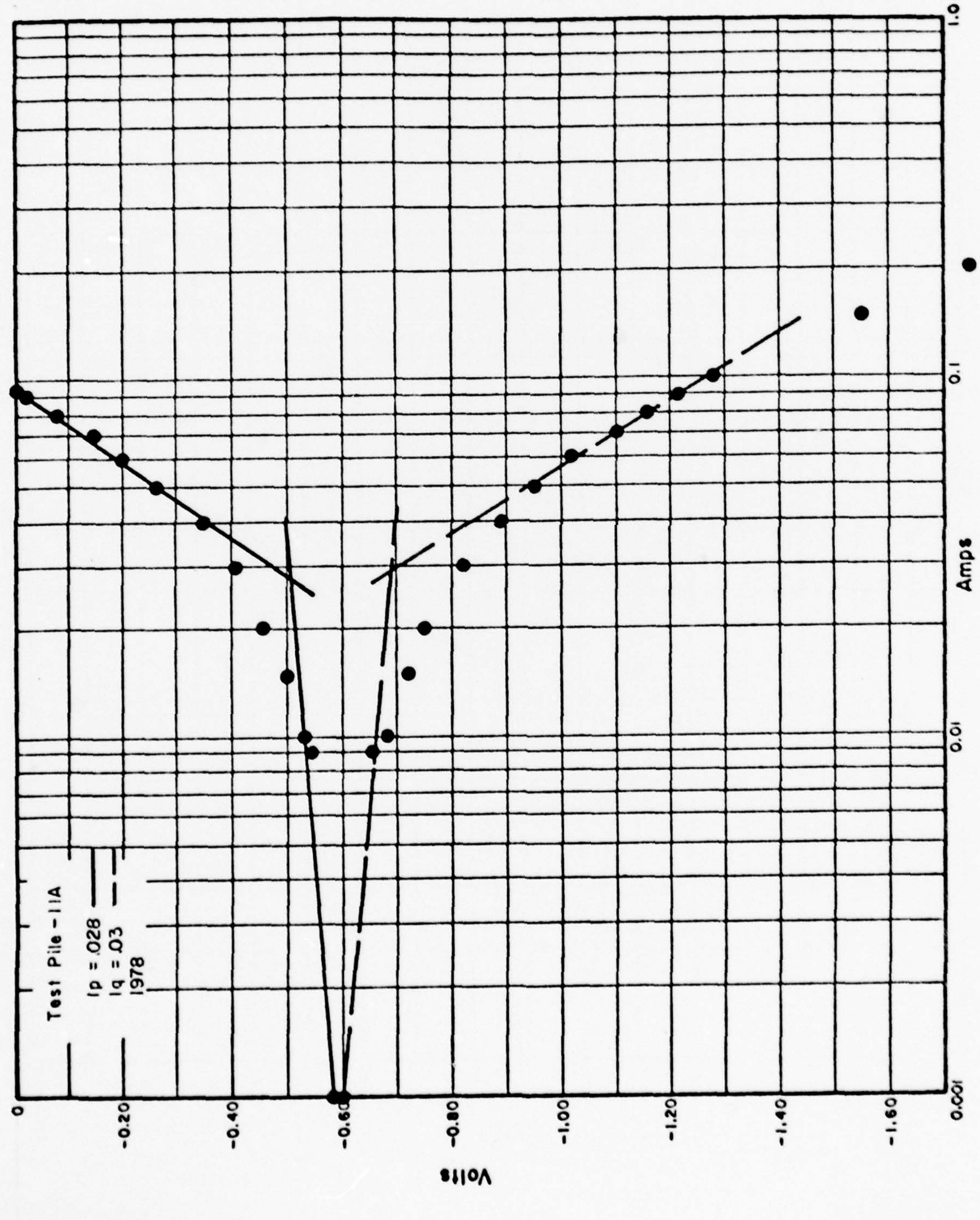

Test Pile - 10 A
Ip = .037
Iq = .027
1978
1.78
Amps
0.001
0.01
0.1
1.0
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60

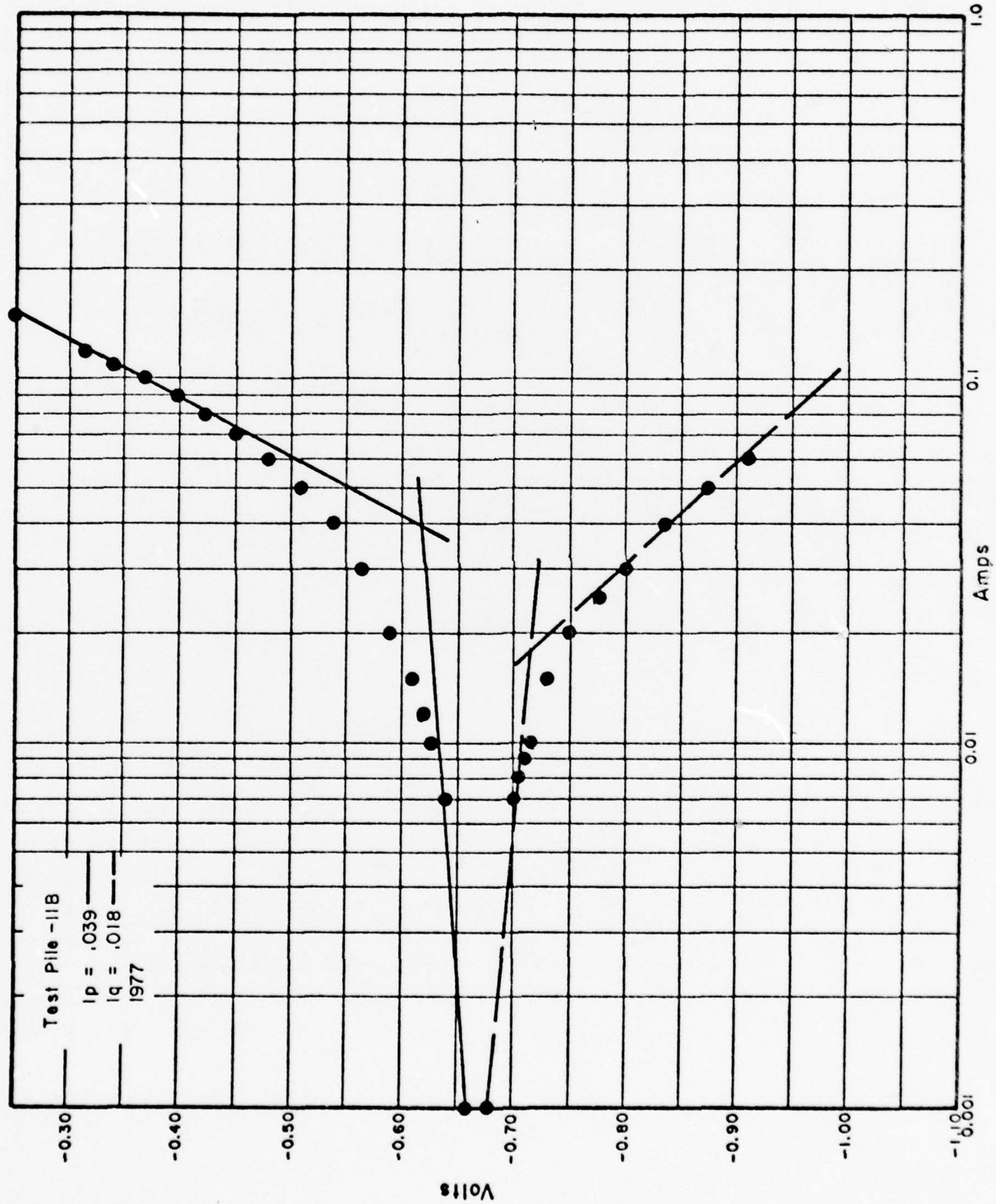

Test Pile-10B
Ip = .041
Iq = .039
1977
Amps
Volts
0.001
0.01
0.1
1.0
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10


Test Pile - 10C
Ip =.057
Iq =.044
1978
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Amps
0.001
0.01
0.1
1.0

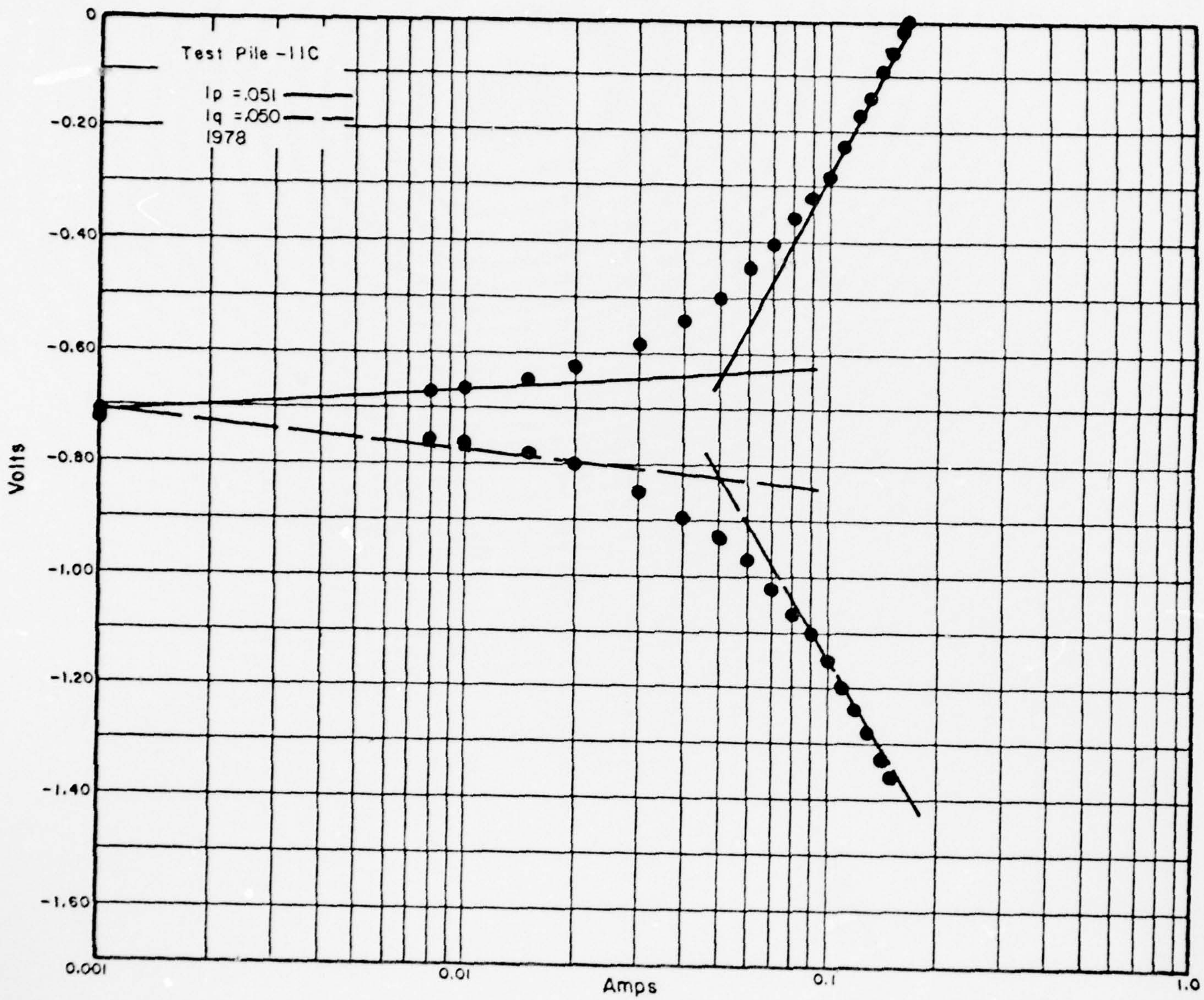


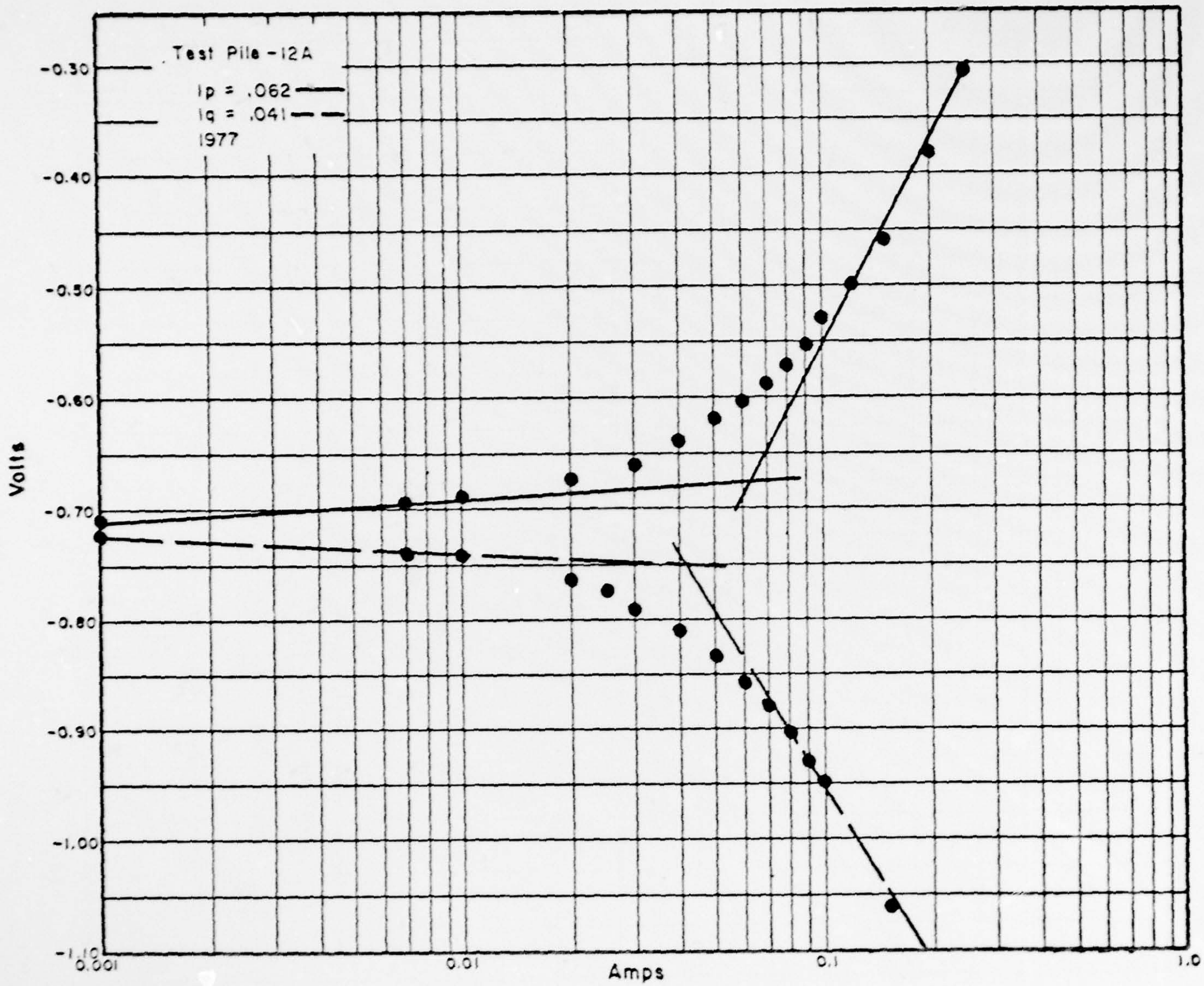
Test Pile - 11A
Ip = .087
Iq = .014
1977
Amps
0.001
0.01
0.1
1.0
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10


Test Pile - 11A
Ip = .028
Iq = .03
1978
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Volts
0.001
0.01
0.1
1.0
Amps

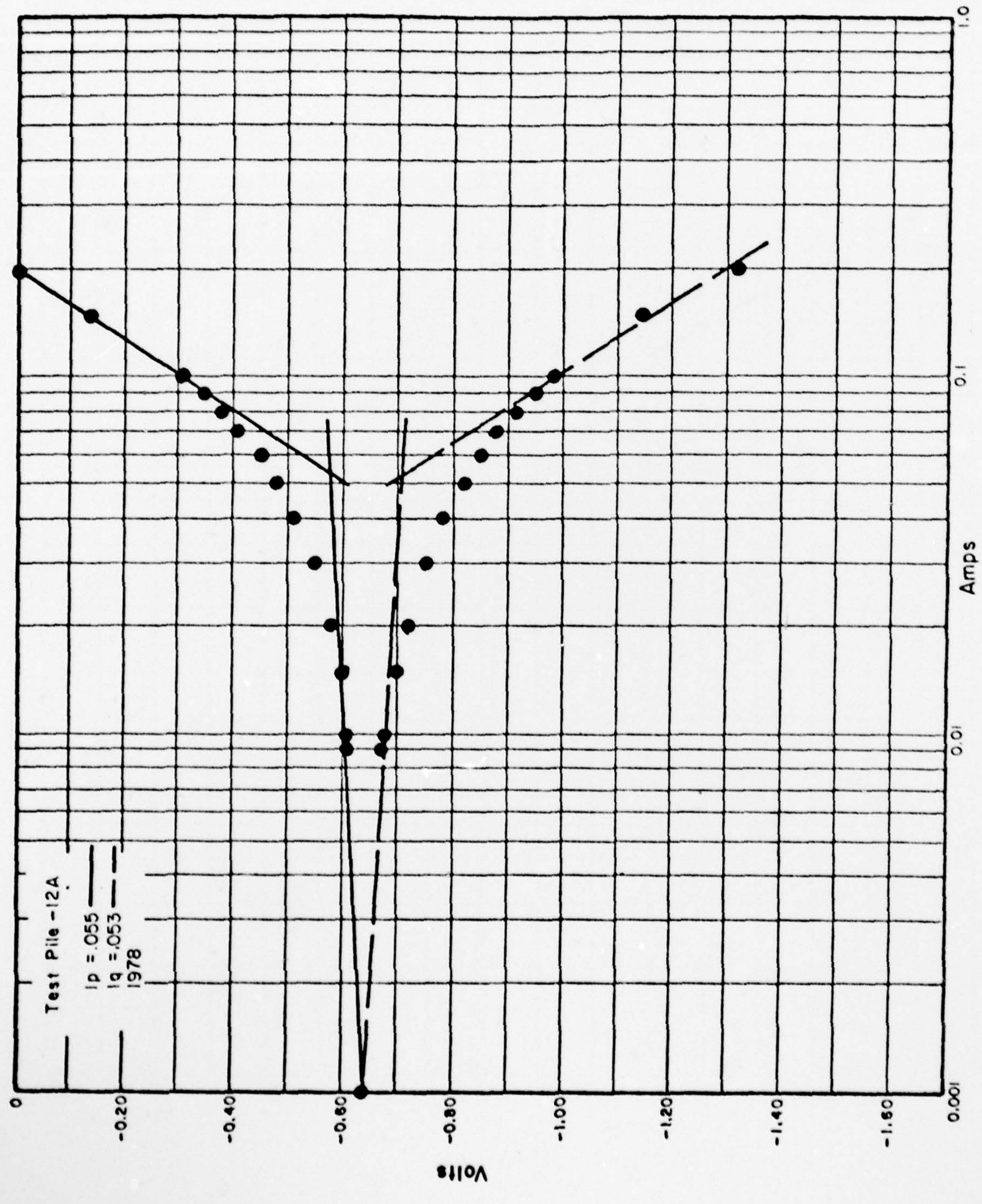


Test Pile -11B
Ip = .039
Iq = .018
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0

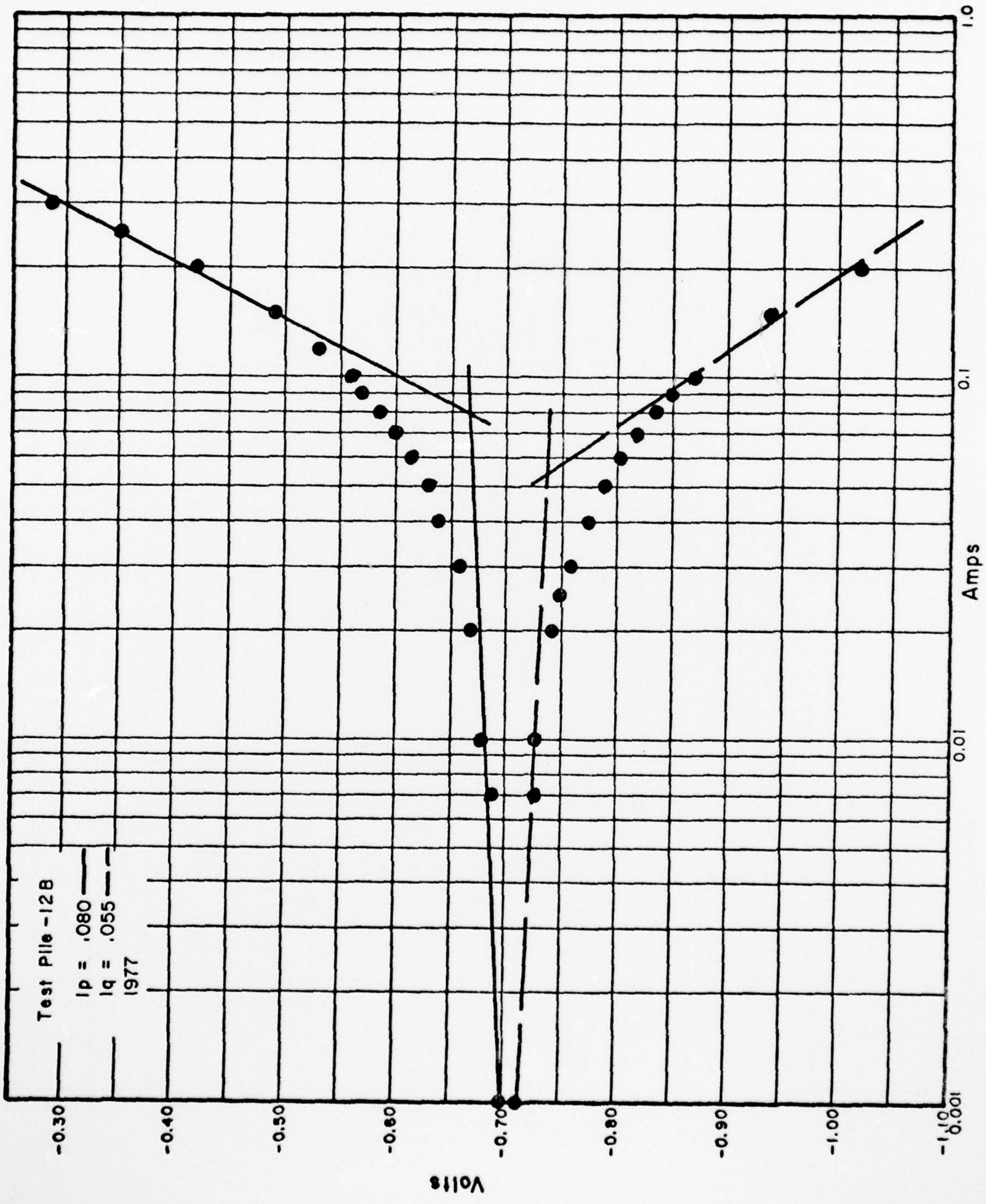

Test Pile - 11C
Ip = .051
Iq = .050
1978
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Volts
0.001
0.01
0.1
1.0
Amps



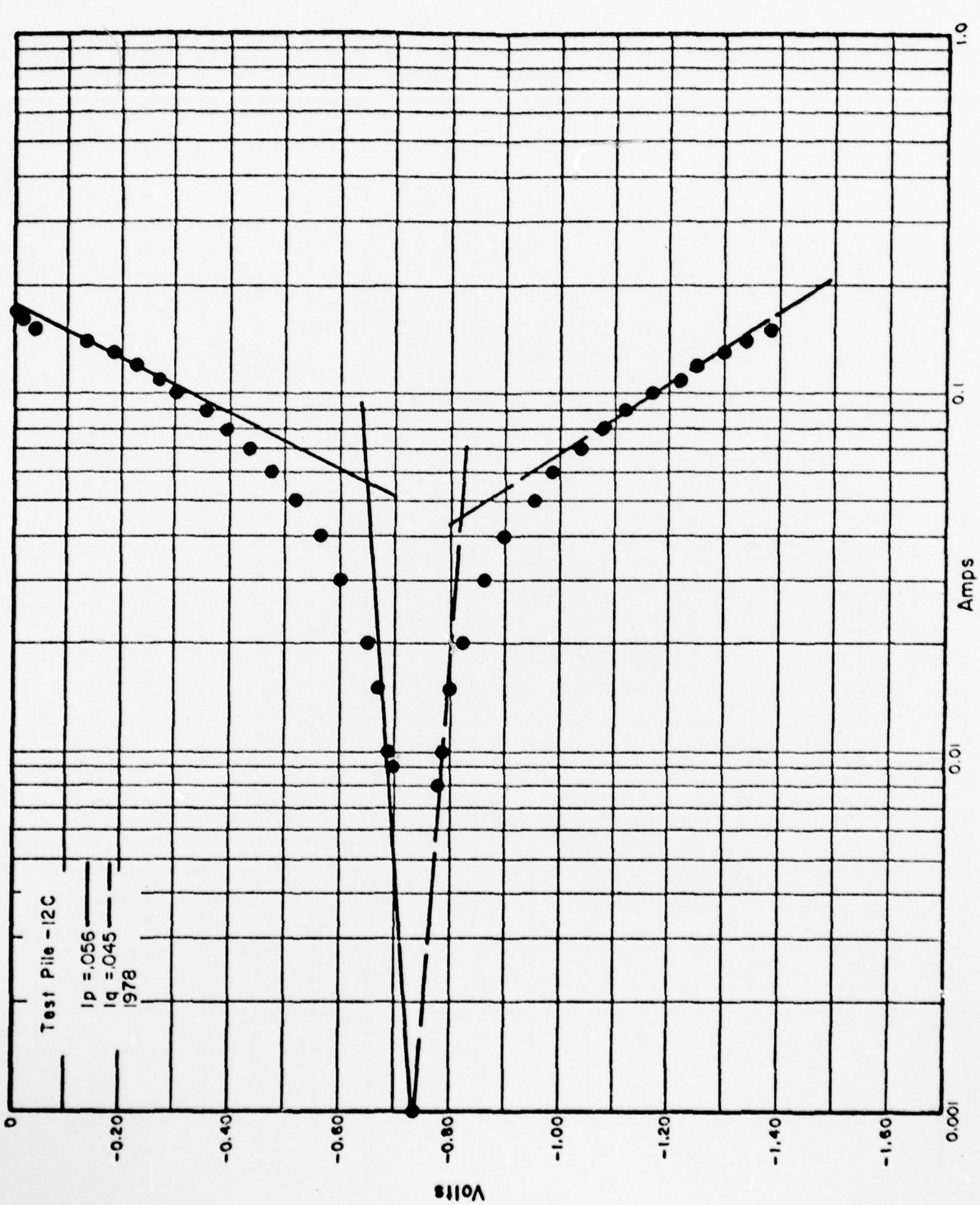
Test Pile - 12A
Ip = .062
Iq = .041
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0

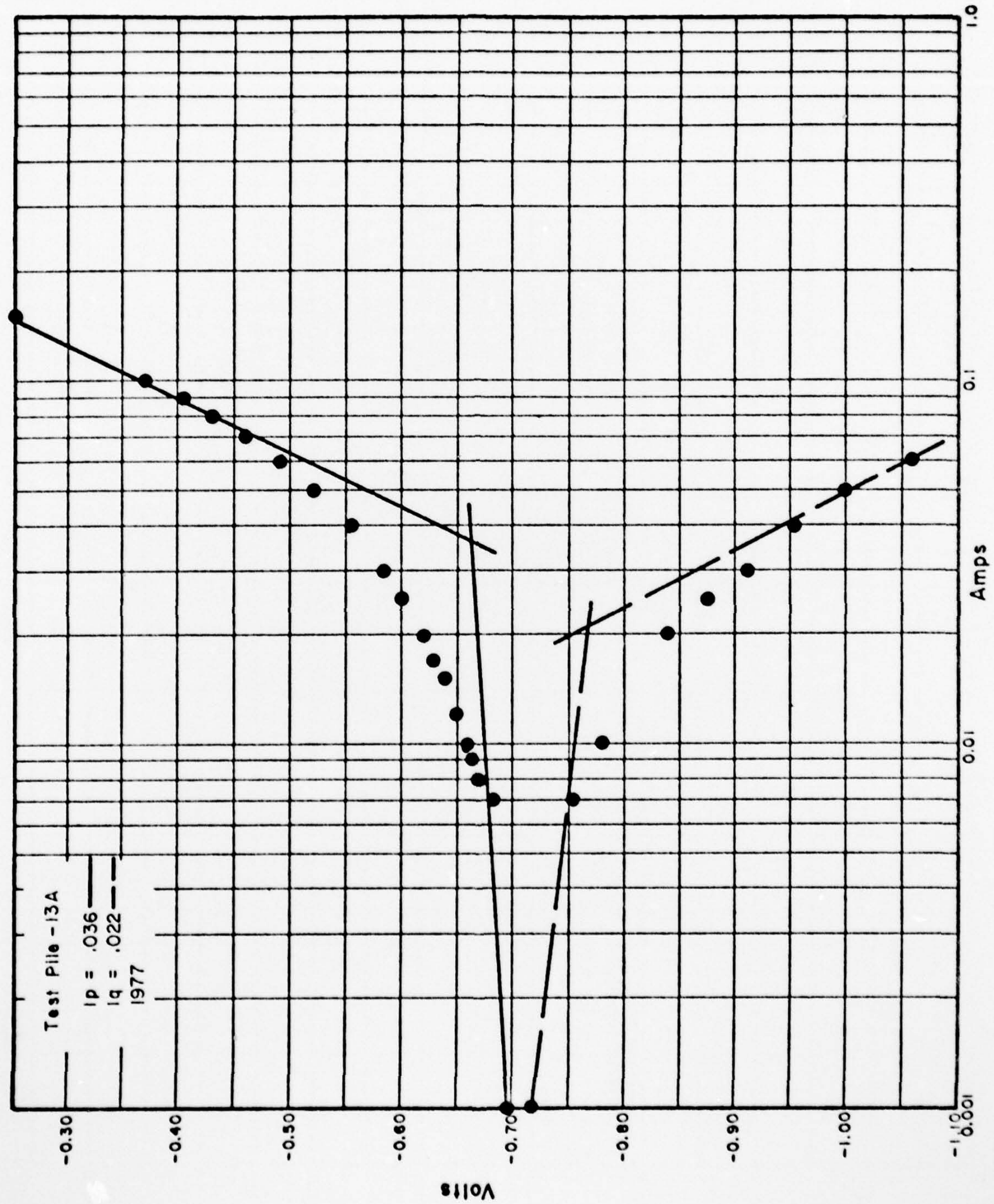


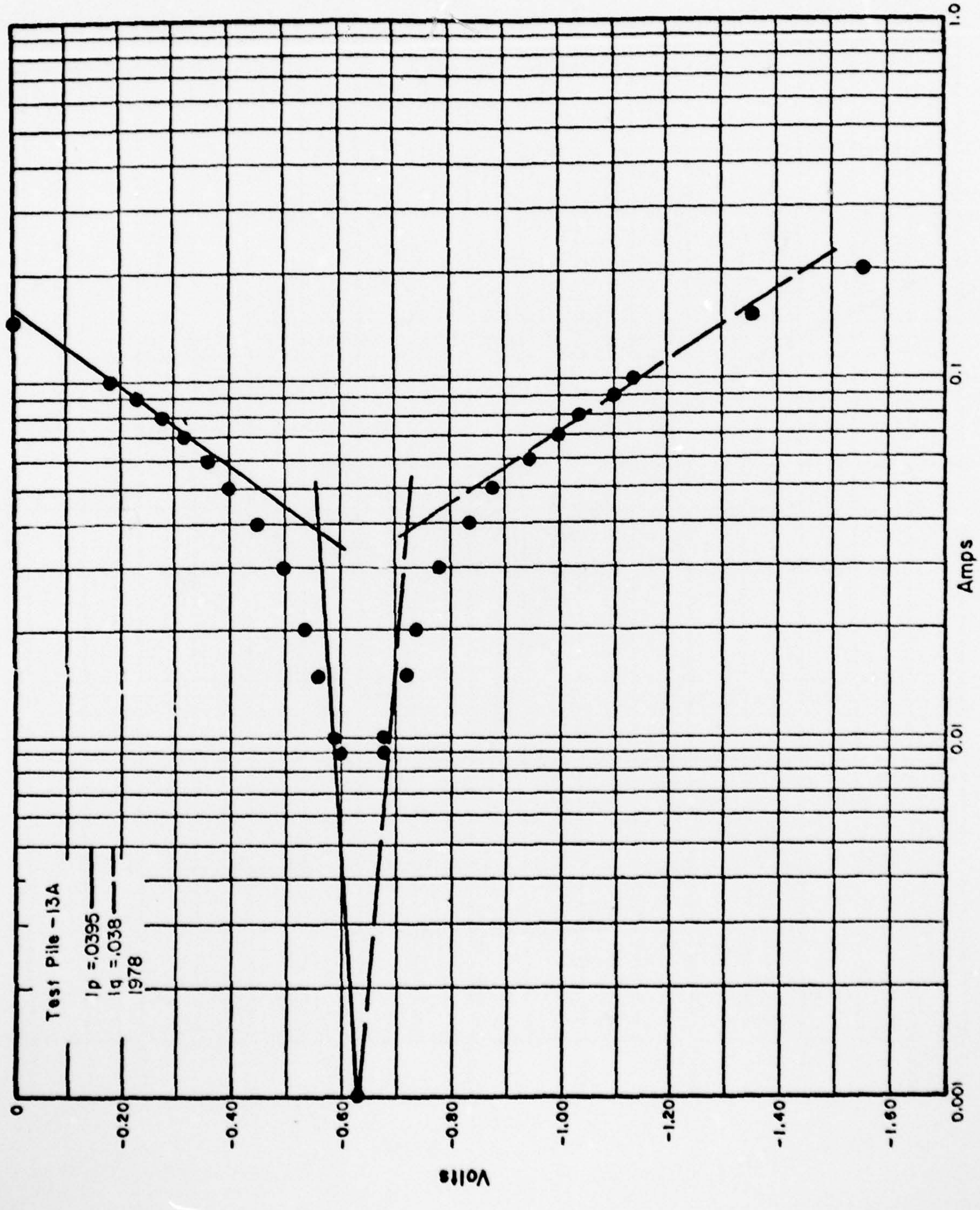
Test Pile -12A
Ip =.055
Iq =.053
1978
Volts
Amps
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

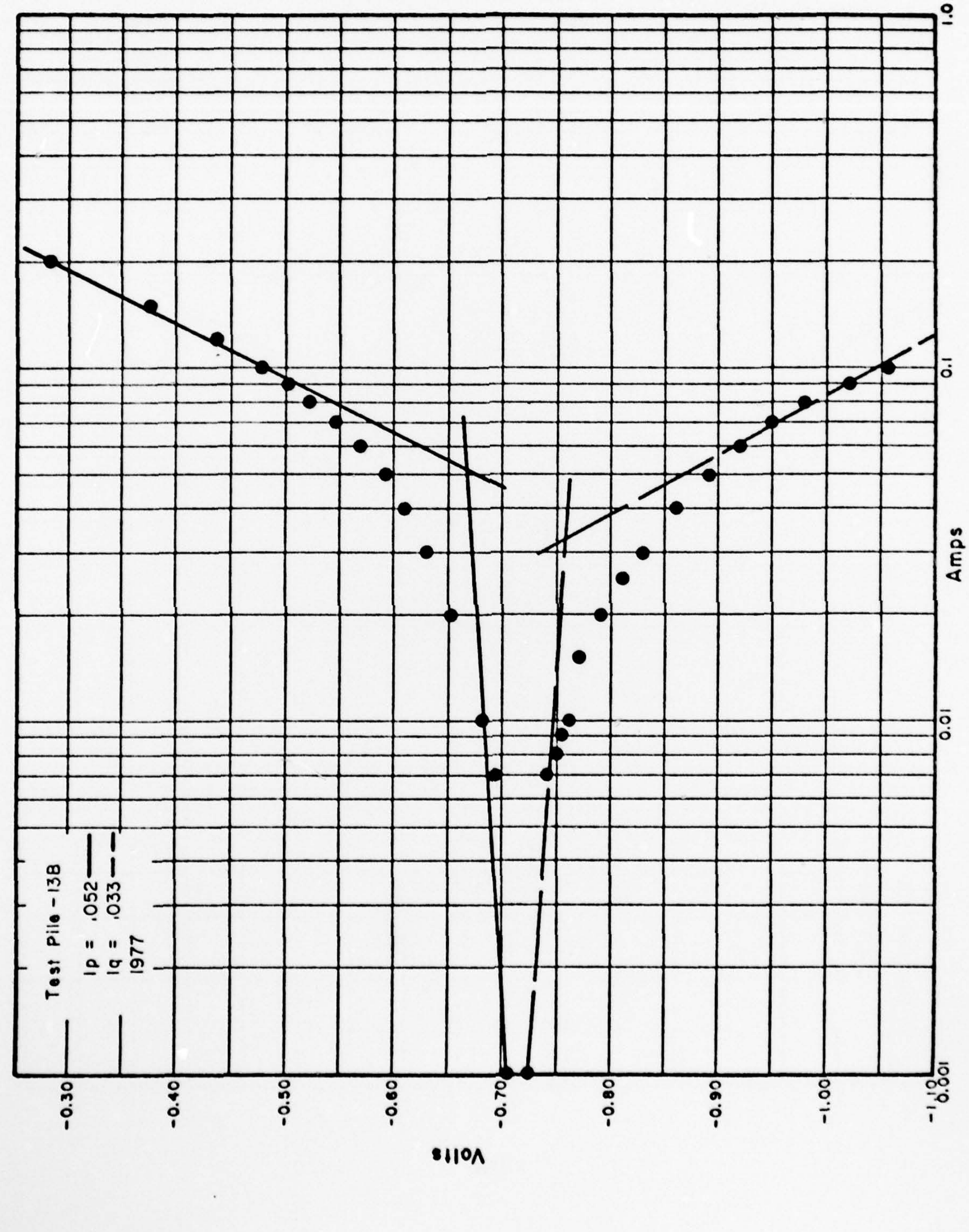


Test Pile -12B
Ip = .080
Iq = .055
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0

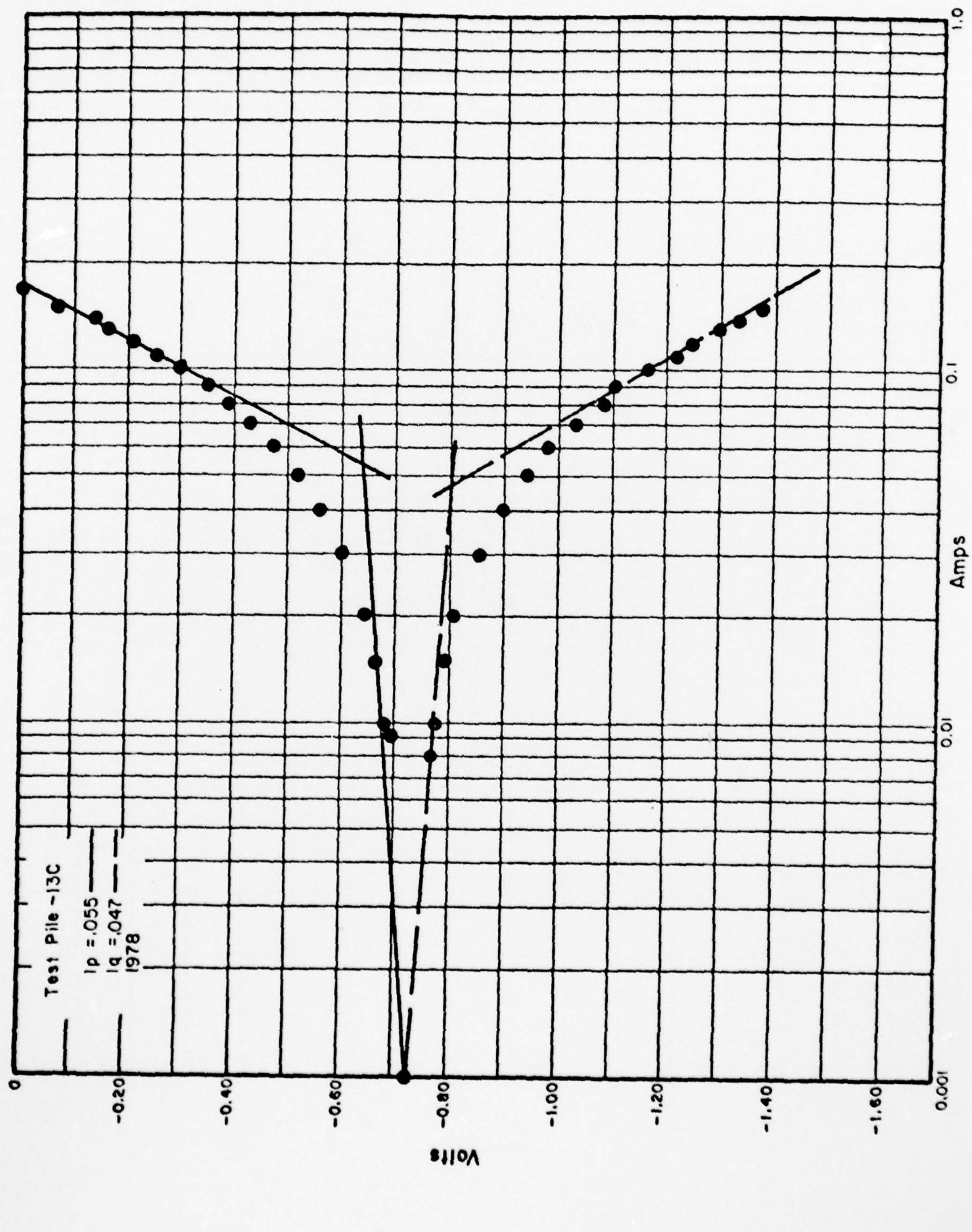

Test Pile -12C
Ip =.056
Iq =.045
1978
Volts
Amps
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

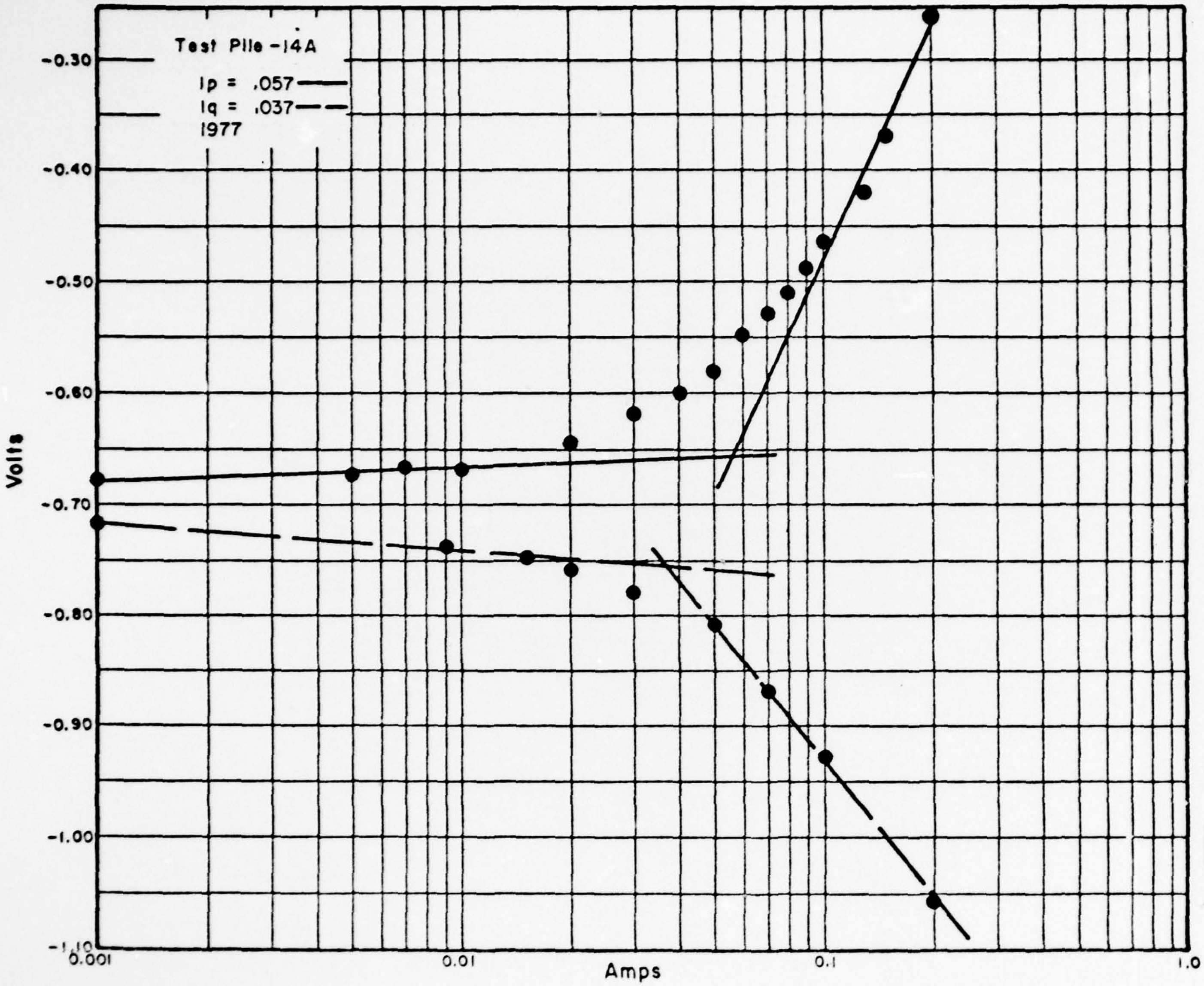

Test Pile - 13A
Ip = .036
Iq = .022
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0


Test Pile - 13A
Ip = .0395
Iq = .038
1978
Volts
Amps
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

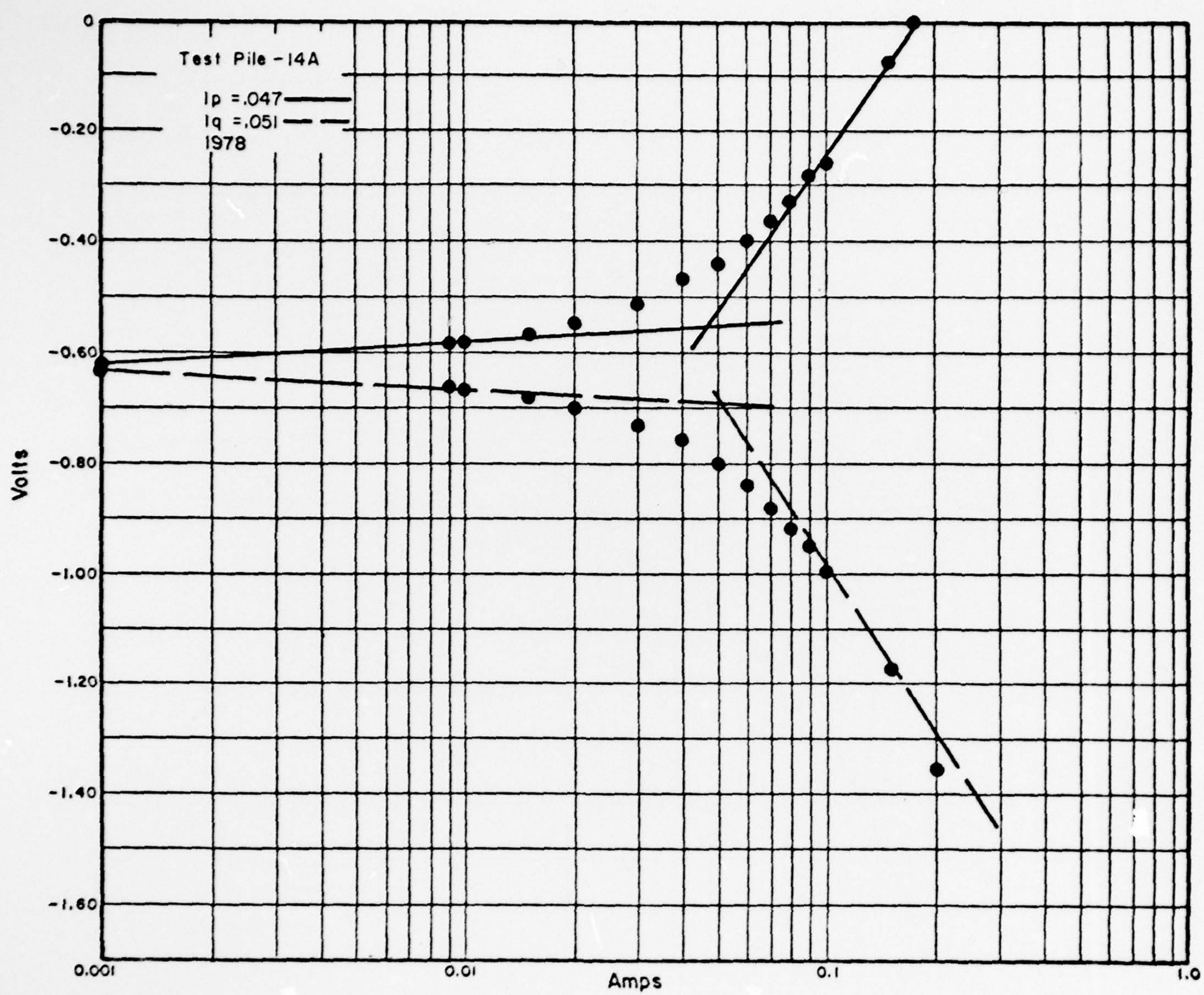


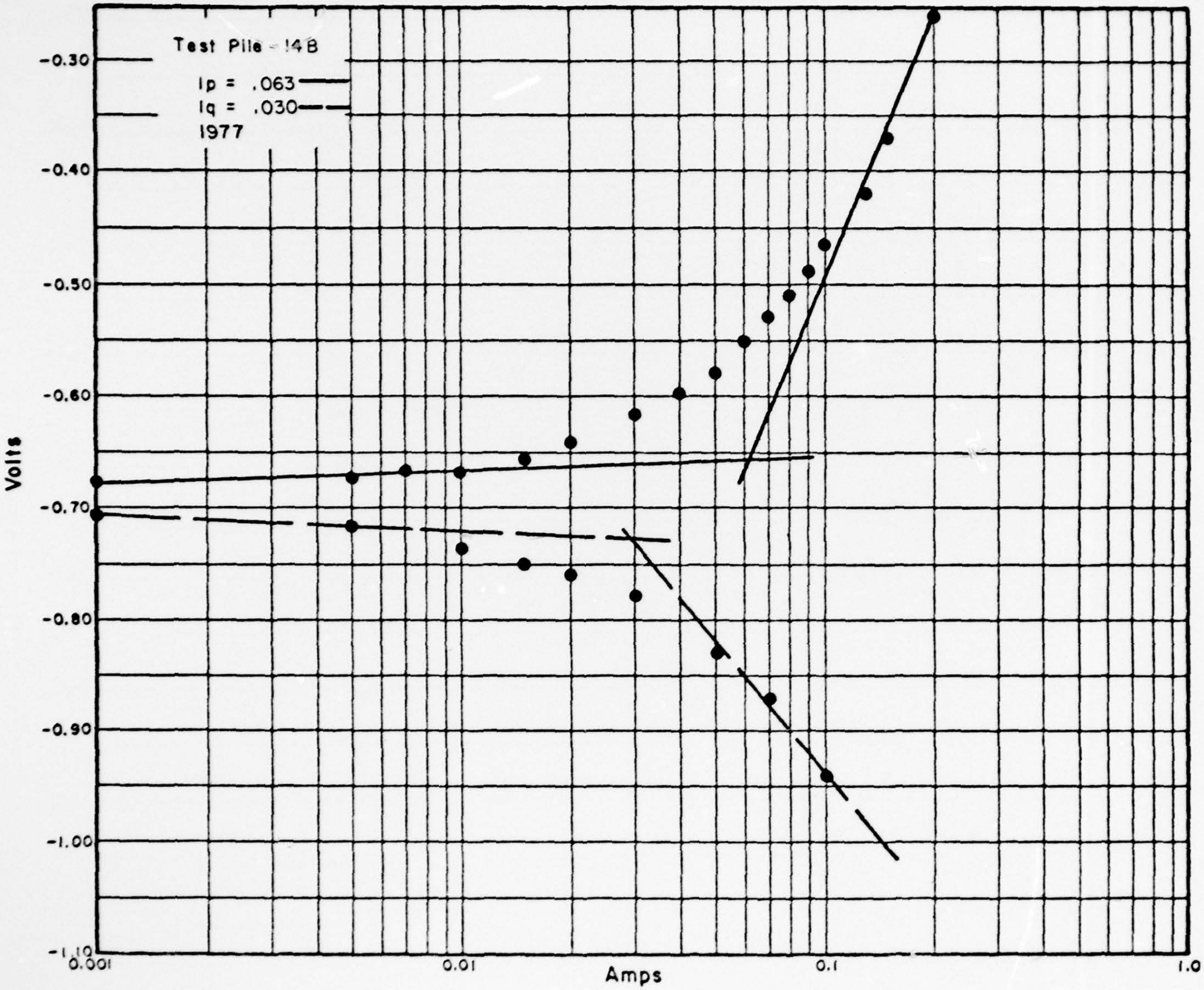
Test Pile - 13B
Ip = .052
Iq = .033
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0

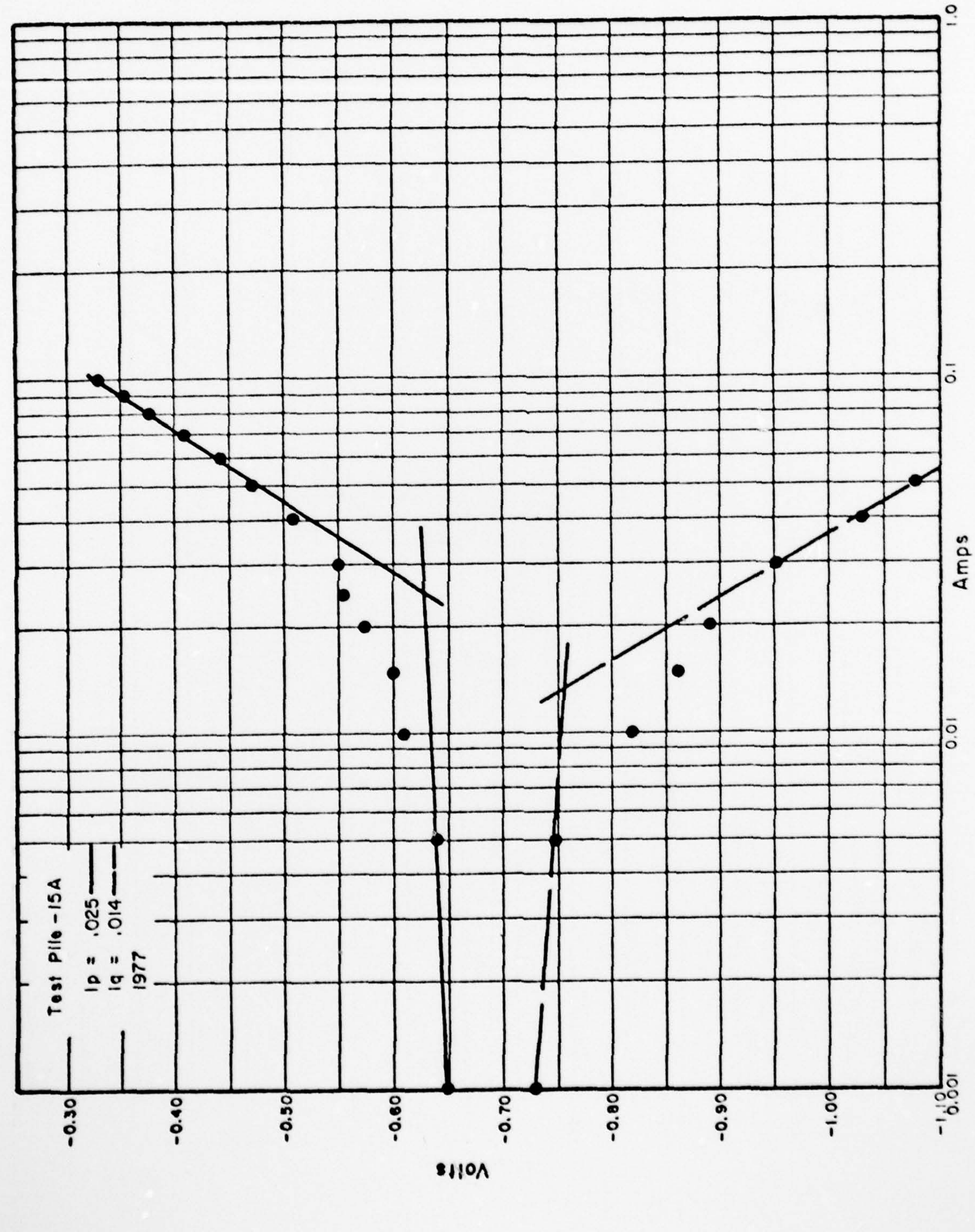

Test Pile -13C
Ip =.055
Iq =.047
1978
Volts
Amps
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

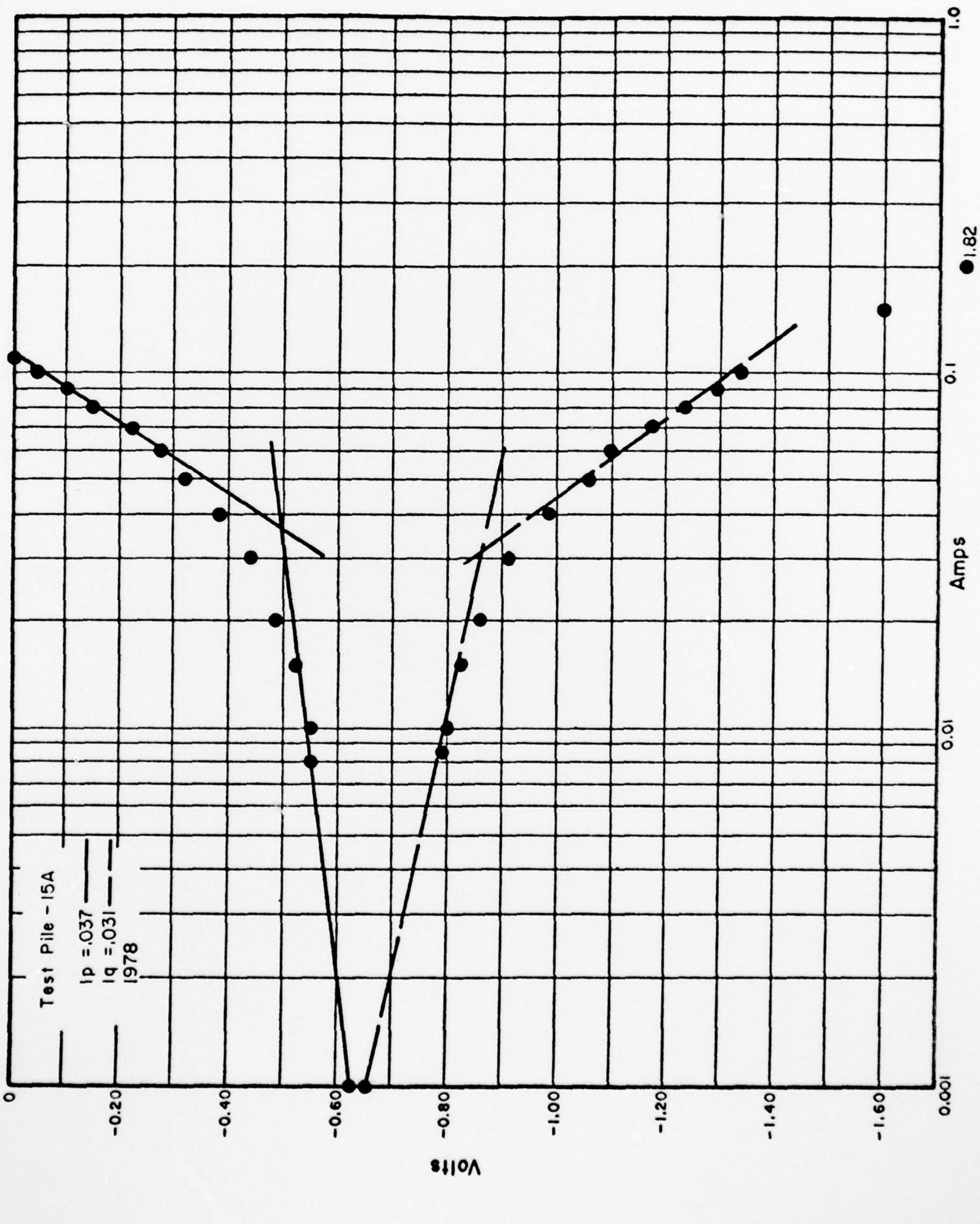


Test Pile -14A
Ip = .057
Iq = .037
1977
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Volts
0.001
0.01
0.1
1.0
Amps

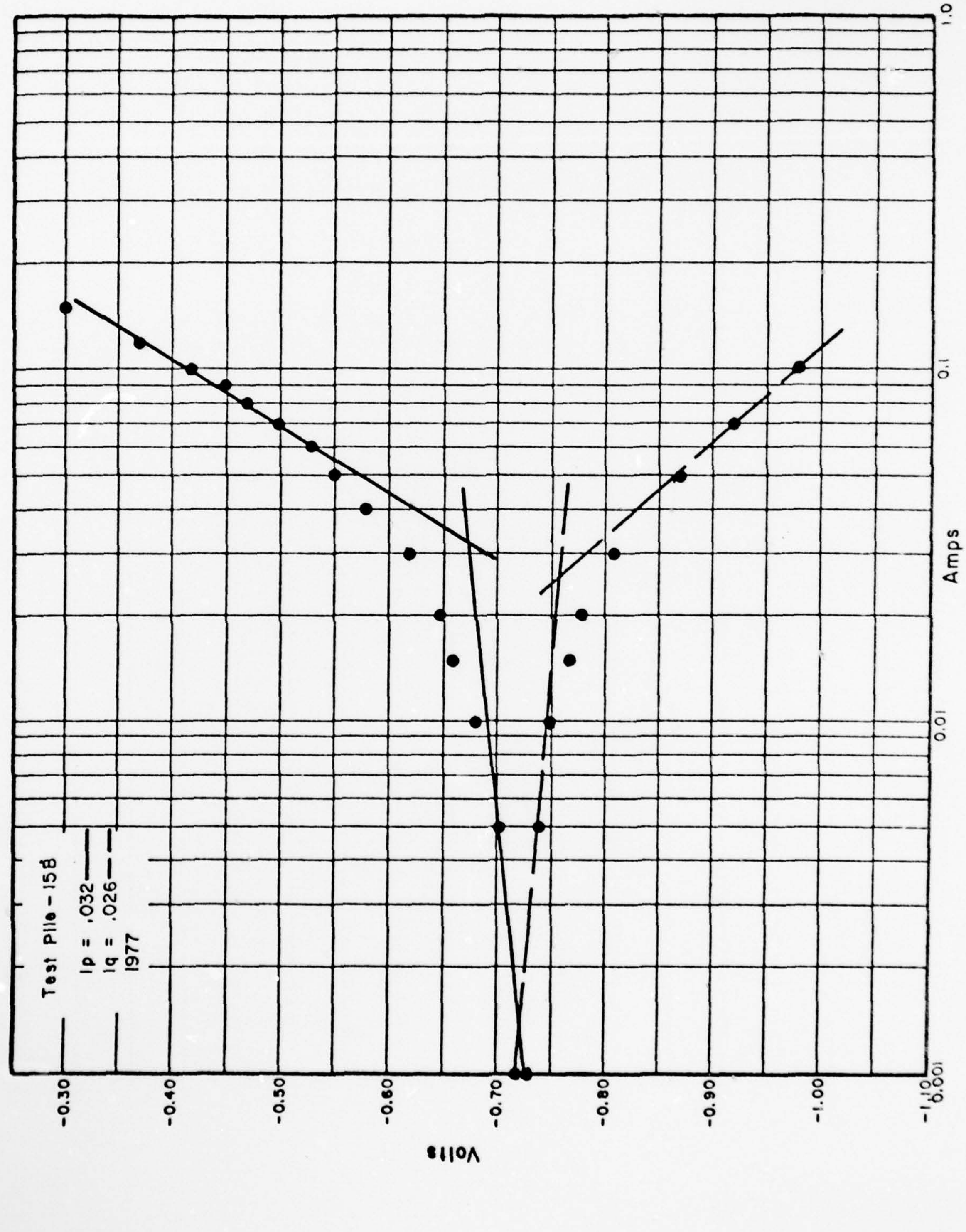

Test Pile - 14A
Ip =.047
Iq =.051
1978
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Volts
0.001
0.01
0.1
1.0
Amps


Test Pile - 14B
Ip = .063
Iq = .030
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0
Amps


Test Pile - 15A
Ip = .025
Iq = .014
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0



Test Pile - 15A
Ip =.037
Iq =.031
1978
1.82
Amps
0.001
0.01
0.1
1.0
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60


Test Pile - 15B
Ip = .032
Iq = .026
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0

AD-A078 626 CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL F/G 13/13
CORROSION OF STEEL PILINGS IN SEAWATER: BUZZARDS BAY -- 1975-19--ETC(U)
NOV 79 F KEARNEY
UNCLASSIFIED CERL-IR-M-275 NL

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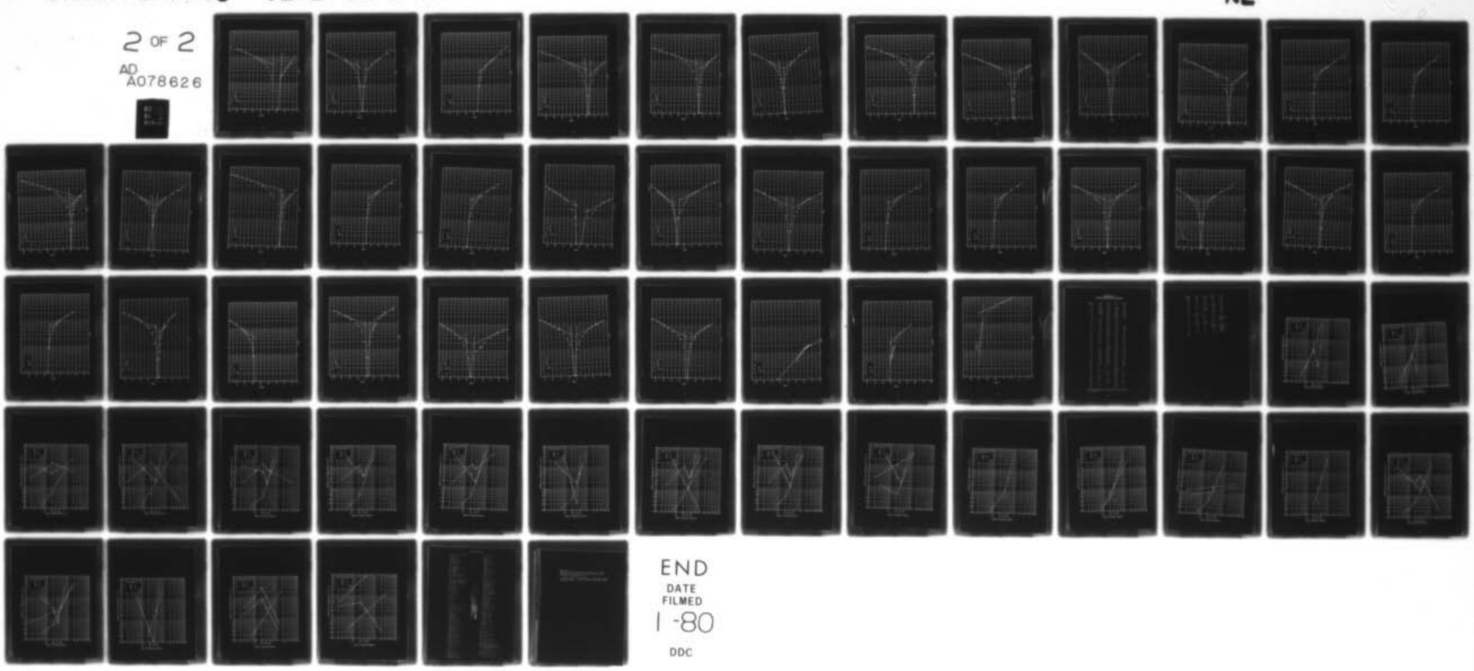
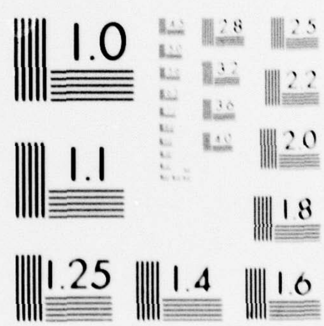
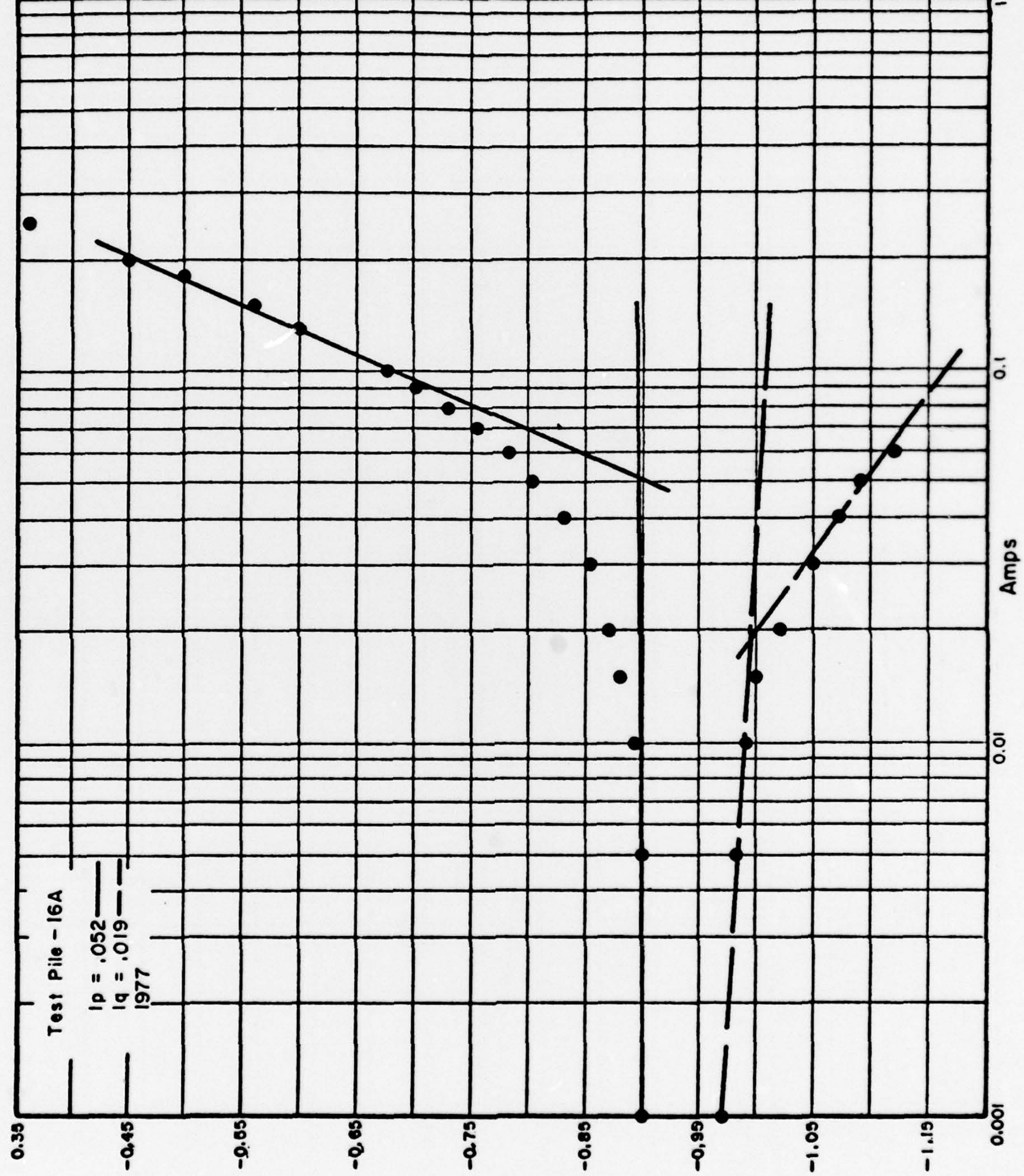


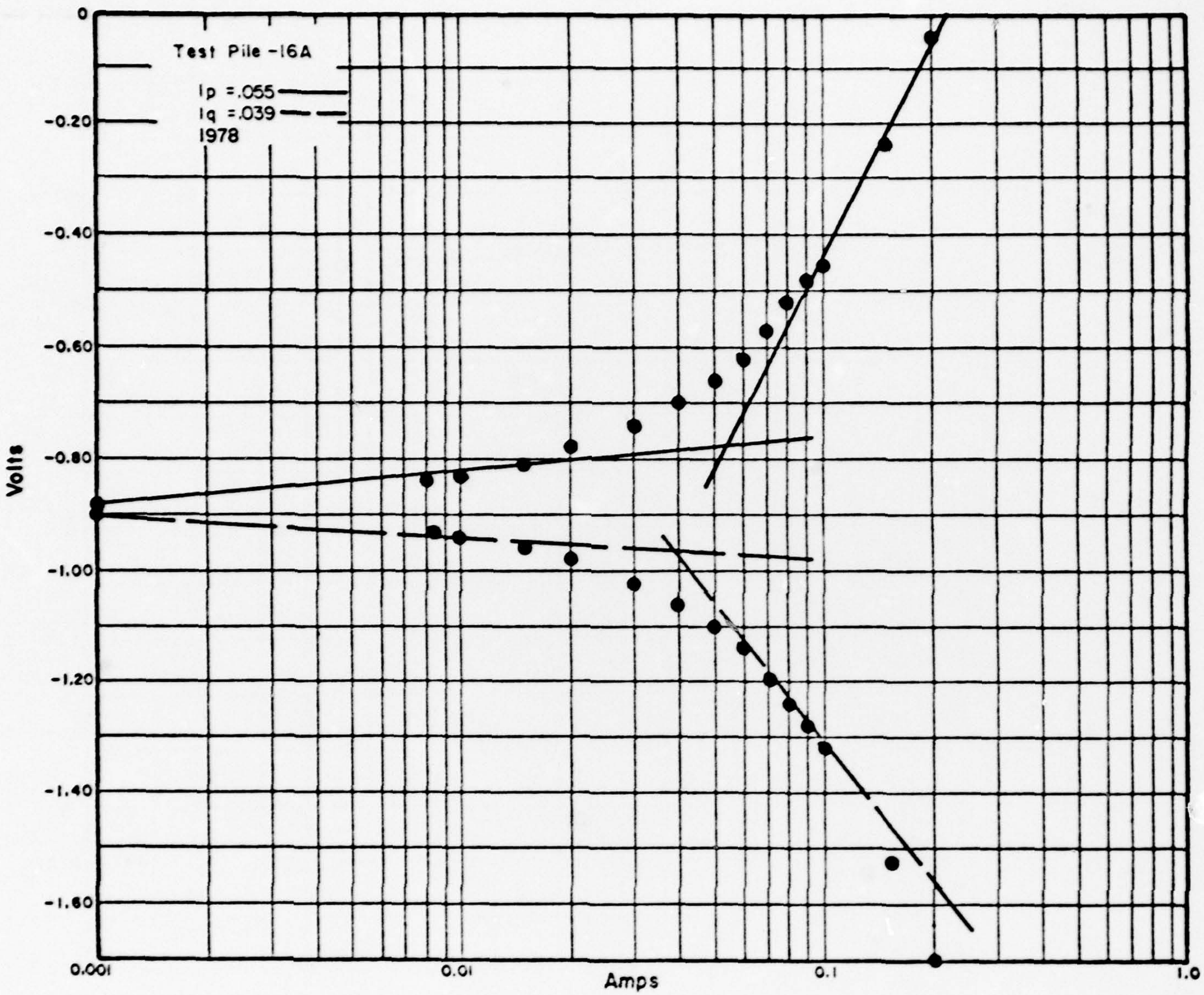
END
DATE
FILMED
1-80
DDC

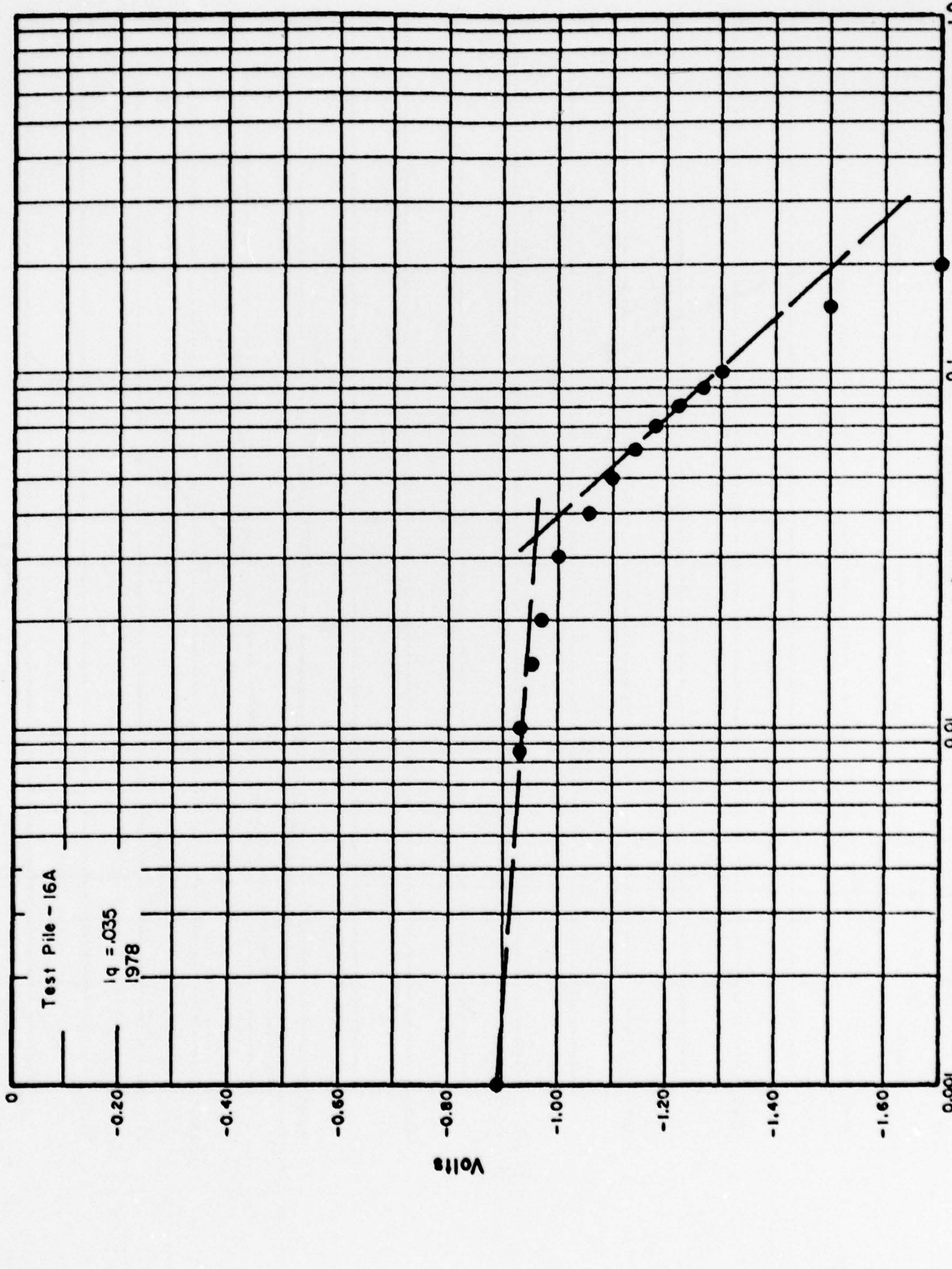


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

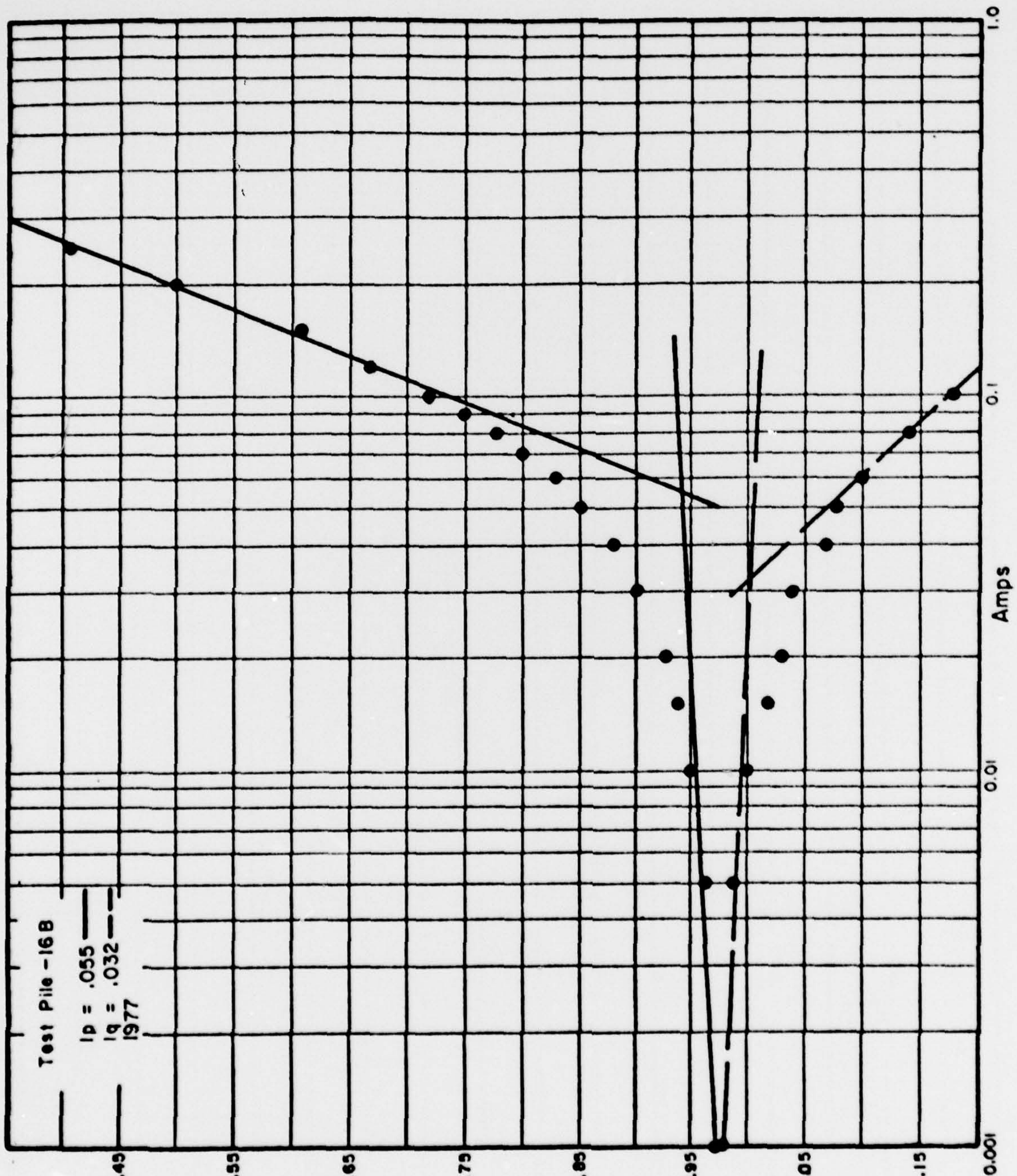


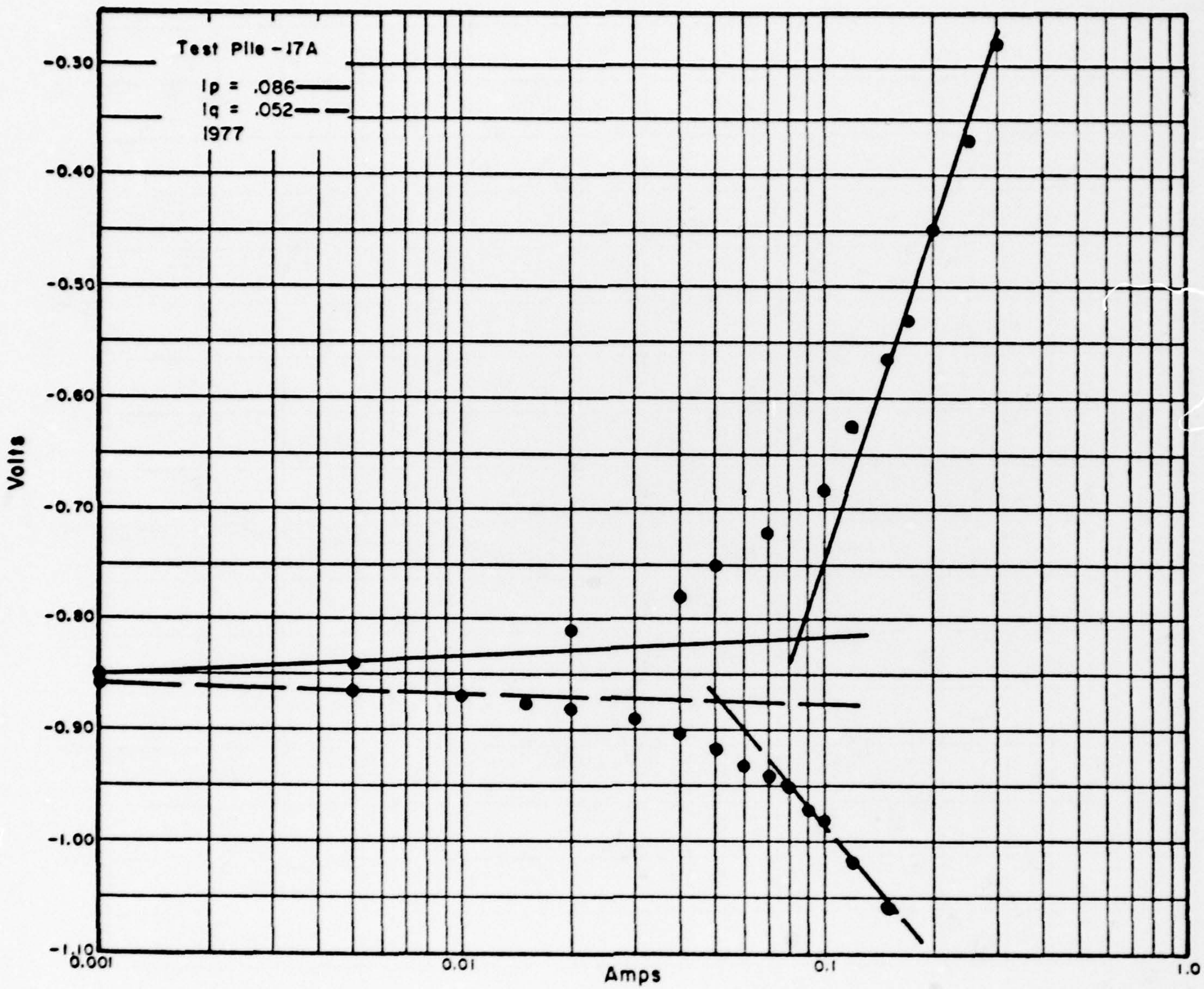
Test Pile - 16A
Ip = .052
Iq = .019
1977
Volts
0.35
-0.45
-0.55
-0.65
-0.75
-0.85
-0.95
-1.05
-1.15
Amps
0.001
0.01
0.1
1.0


Test Pile -16A
Ip =.055
Iq =.039
1978
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Volts
0.001
0.01
0.1
1.0
Amps



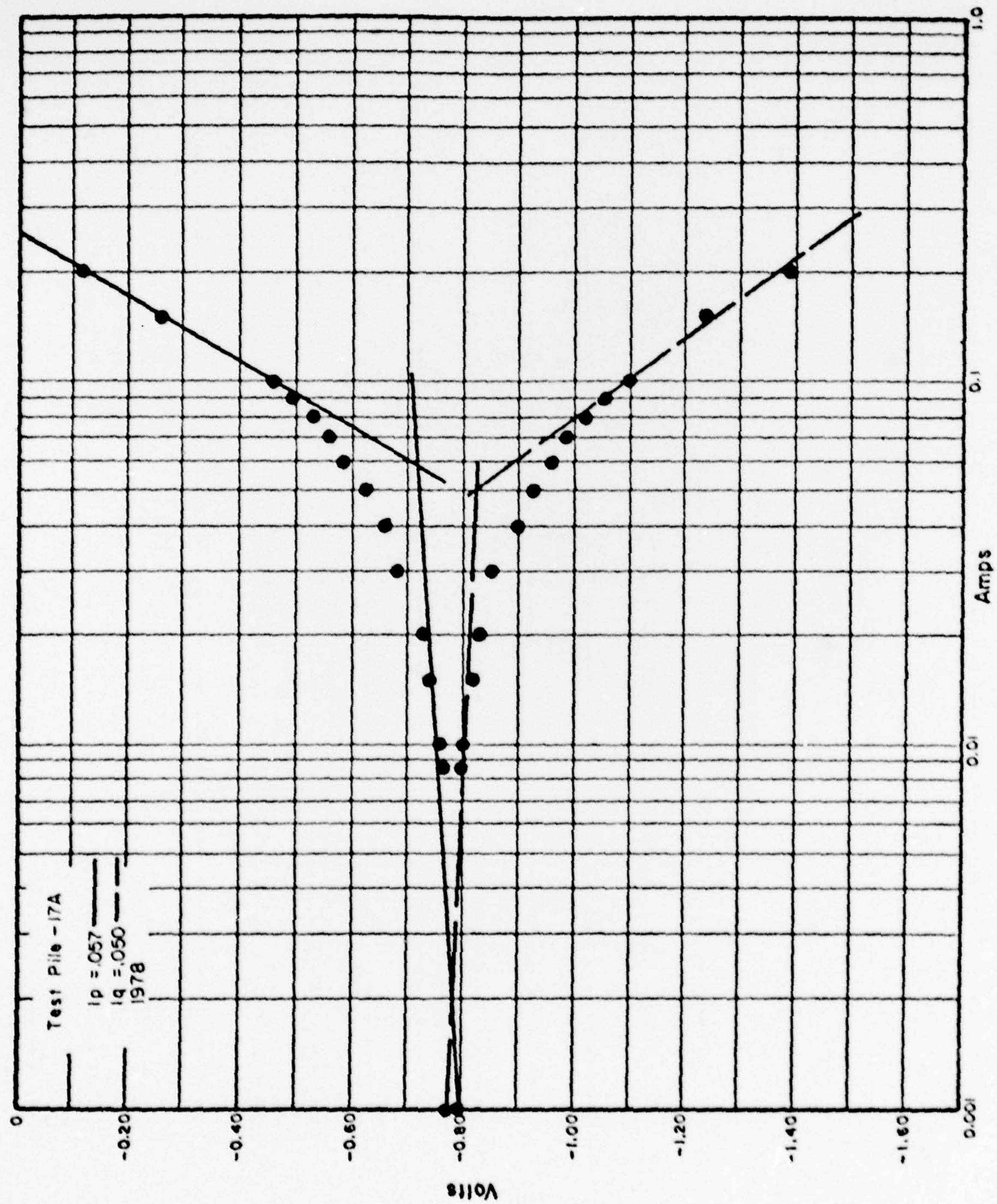
Test Pile - 16A
Iq =.035
1978
Amps
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0


Test Pile -16B
Ip = .055
Iq = .032
1977
Volts
-0.45
-0.55
-0.65
-0.75
-0.85
-0.95
-1.05
-1.15
Amps
0.001
0.01
0.1
1.0

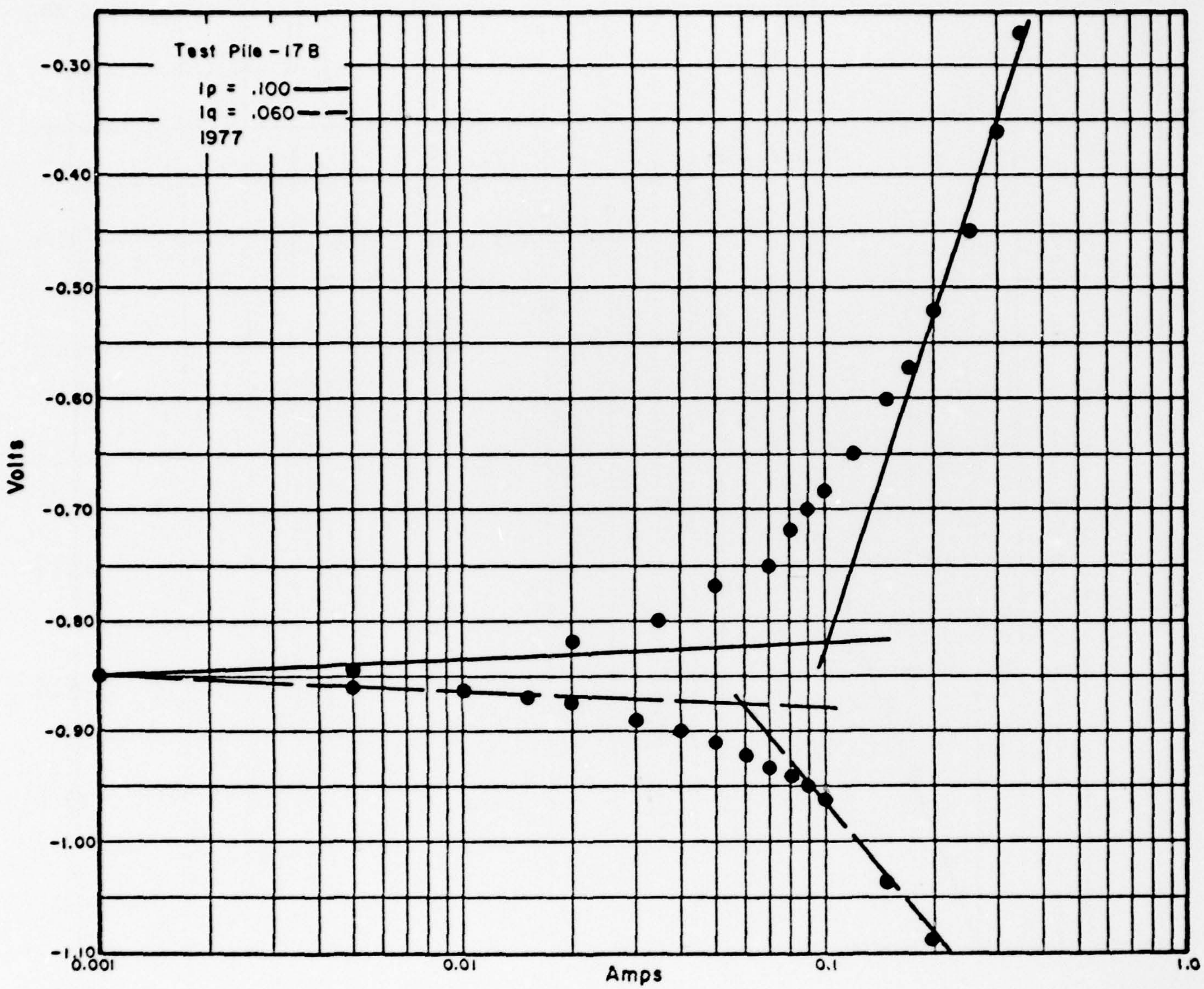


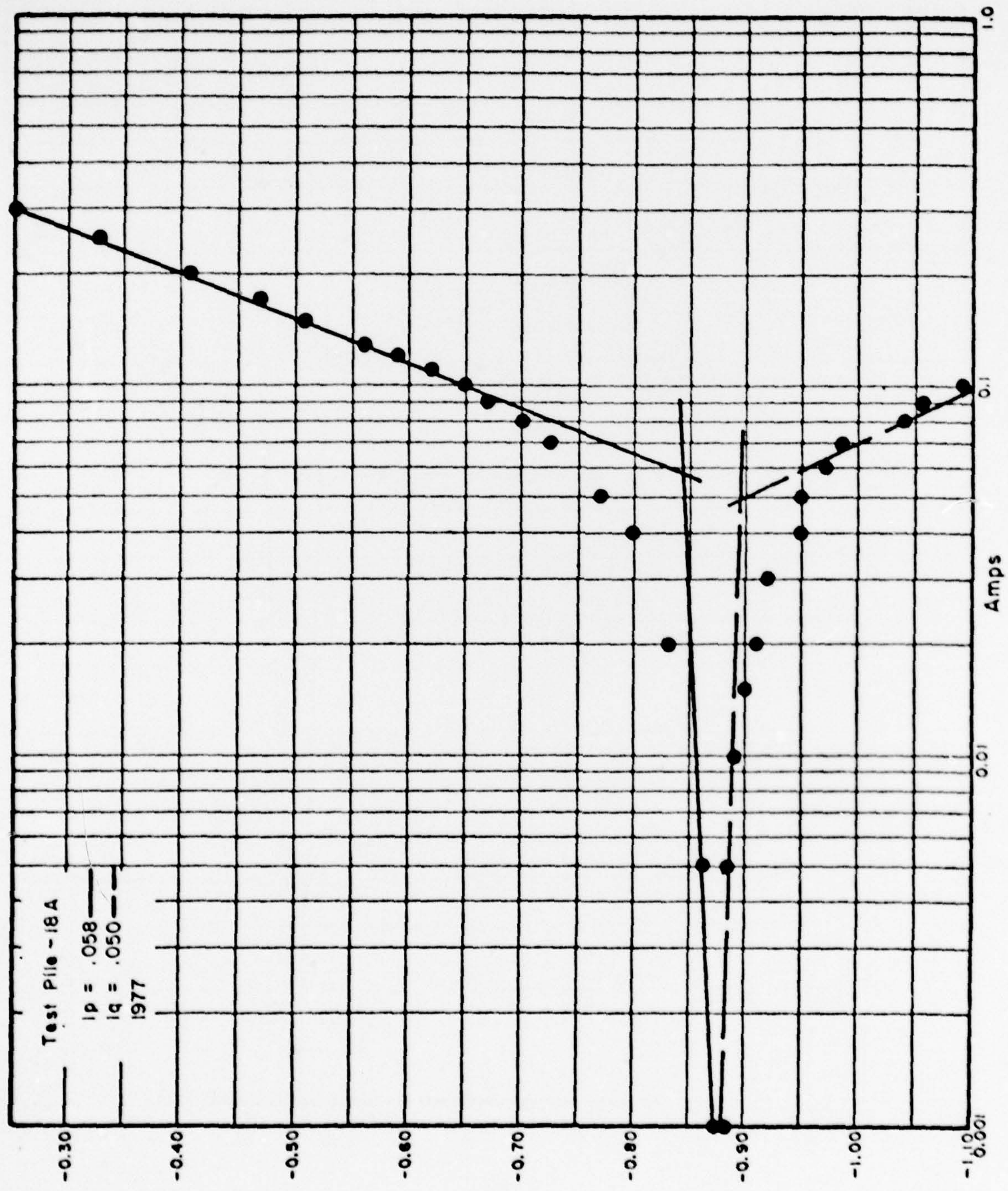
Test Pile - 17A
Ip = .086
Iq = .052
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0
Amps

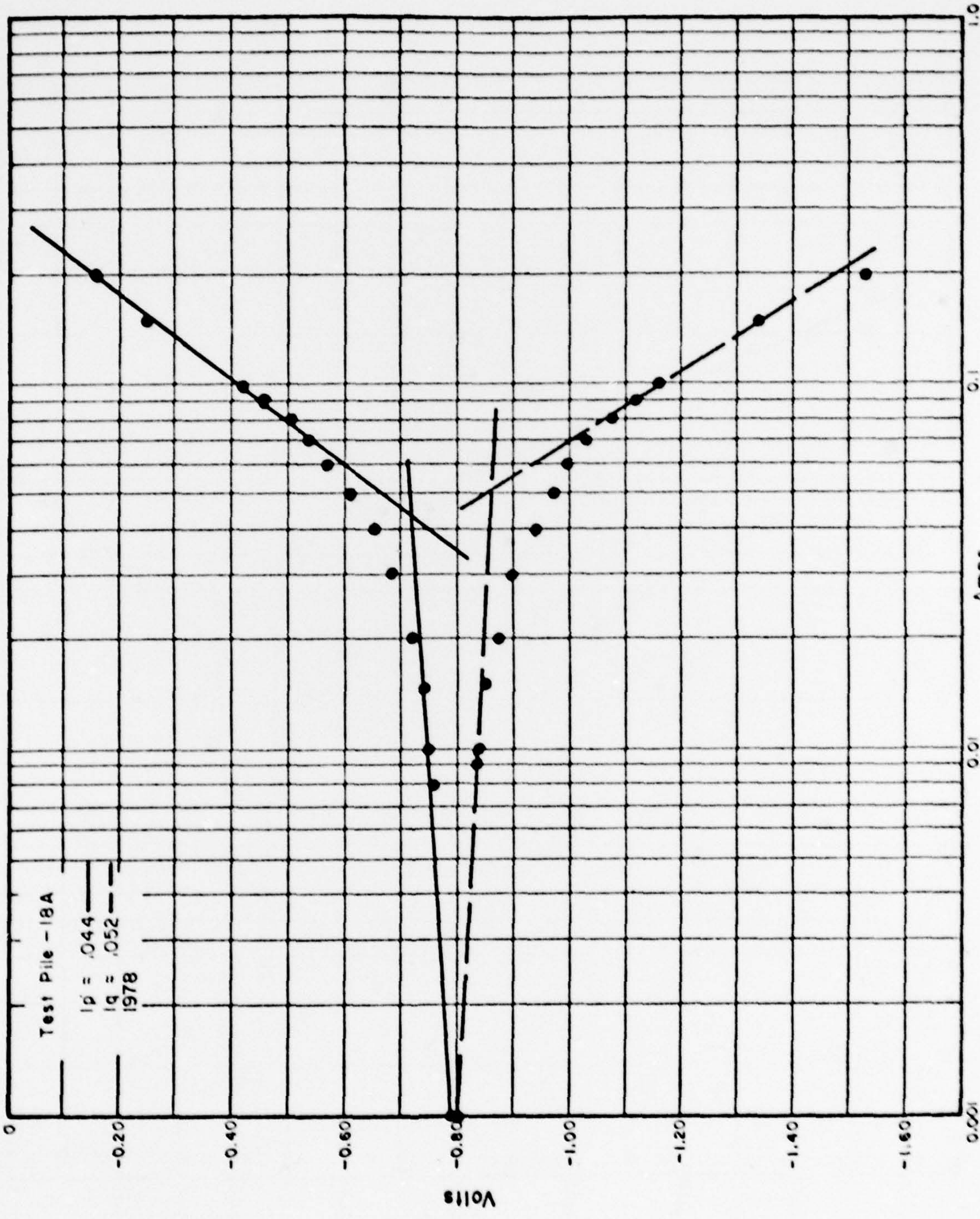
100

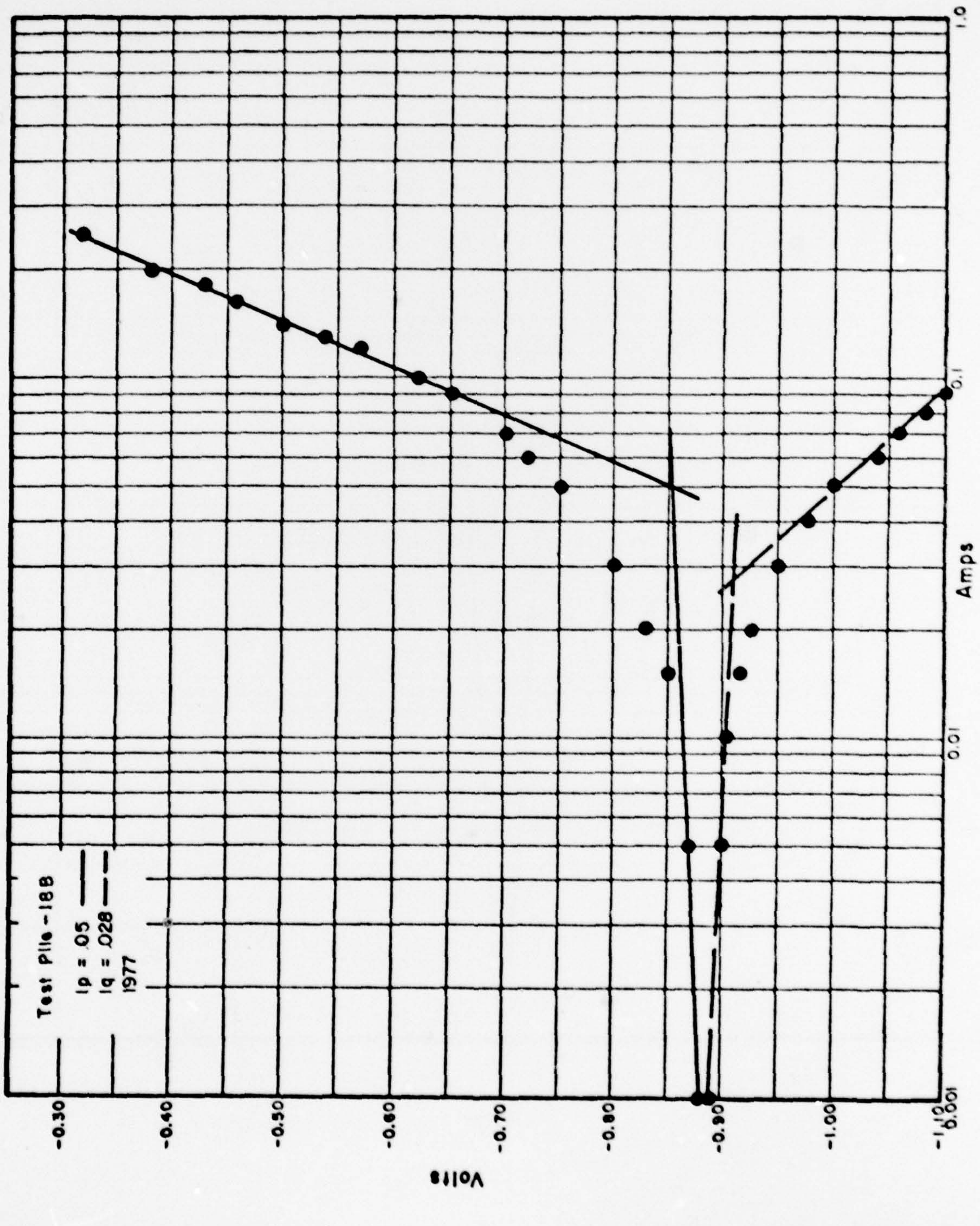


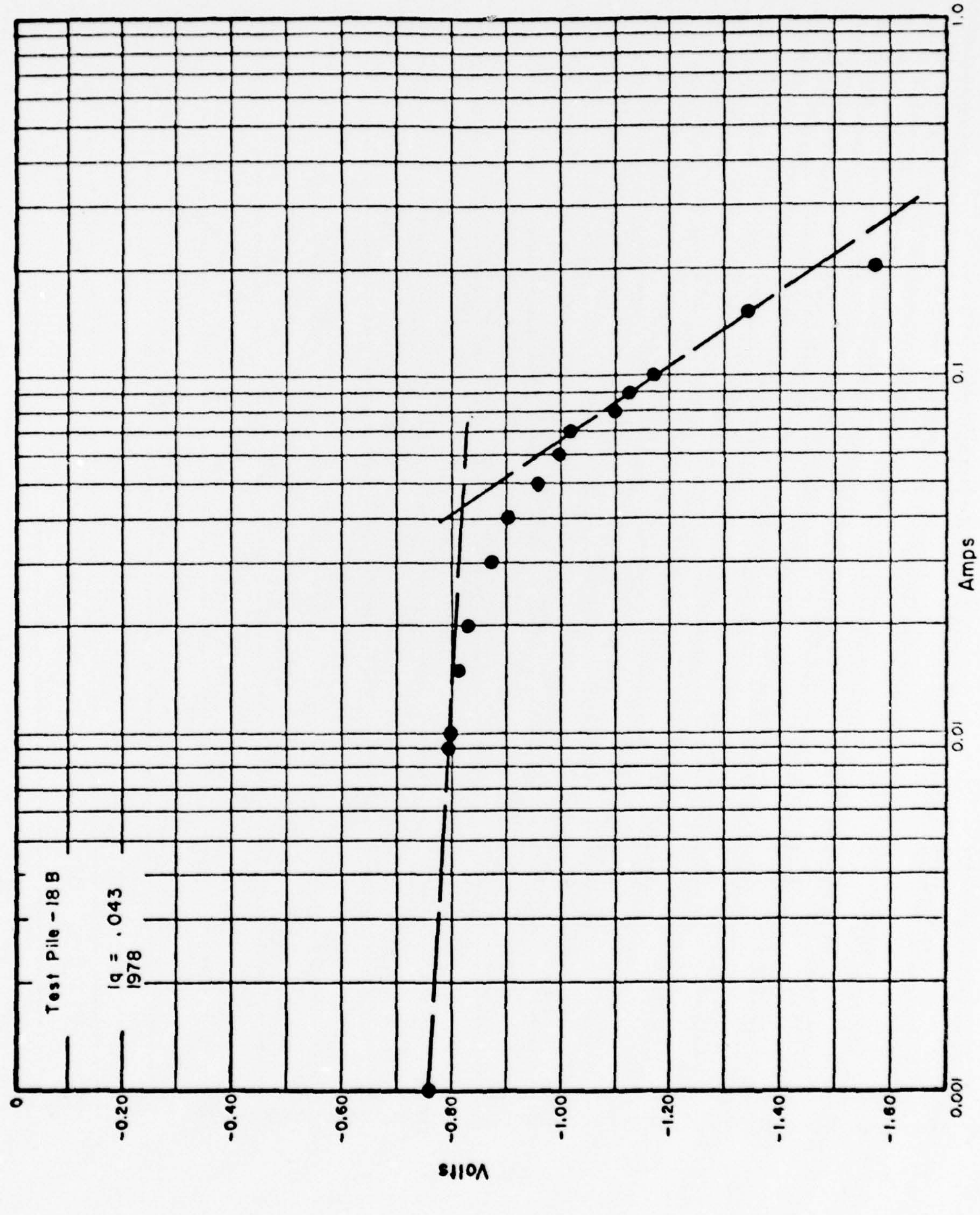
Test Pile - 17A
Ip = .057
Iq = .050
1978
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Amps
0.001
0.01
0.1
1.0

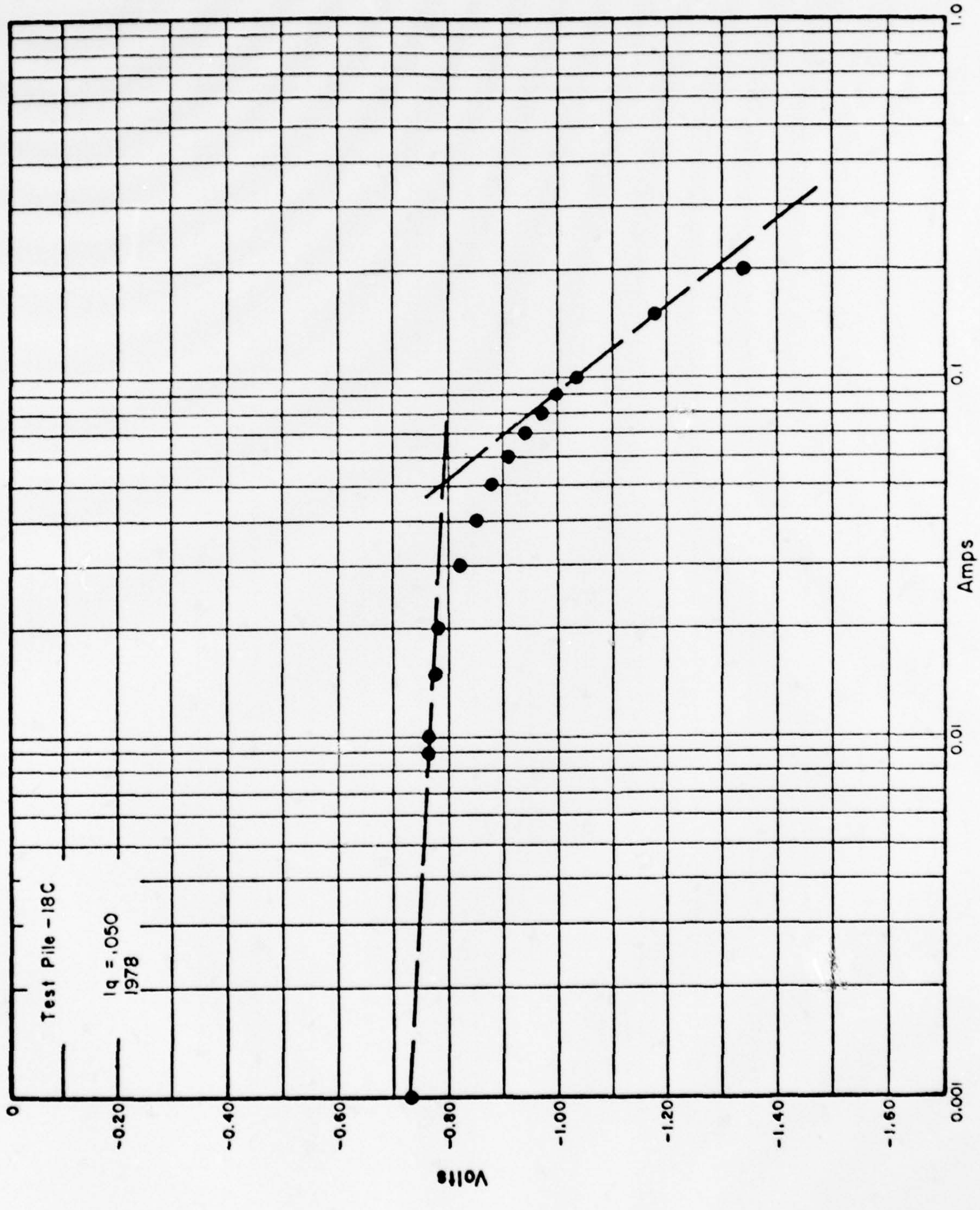

Test Pile - 17B
Ip = .100
Iq = .060
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0

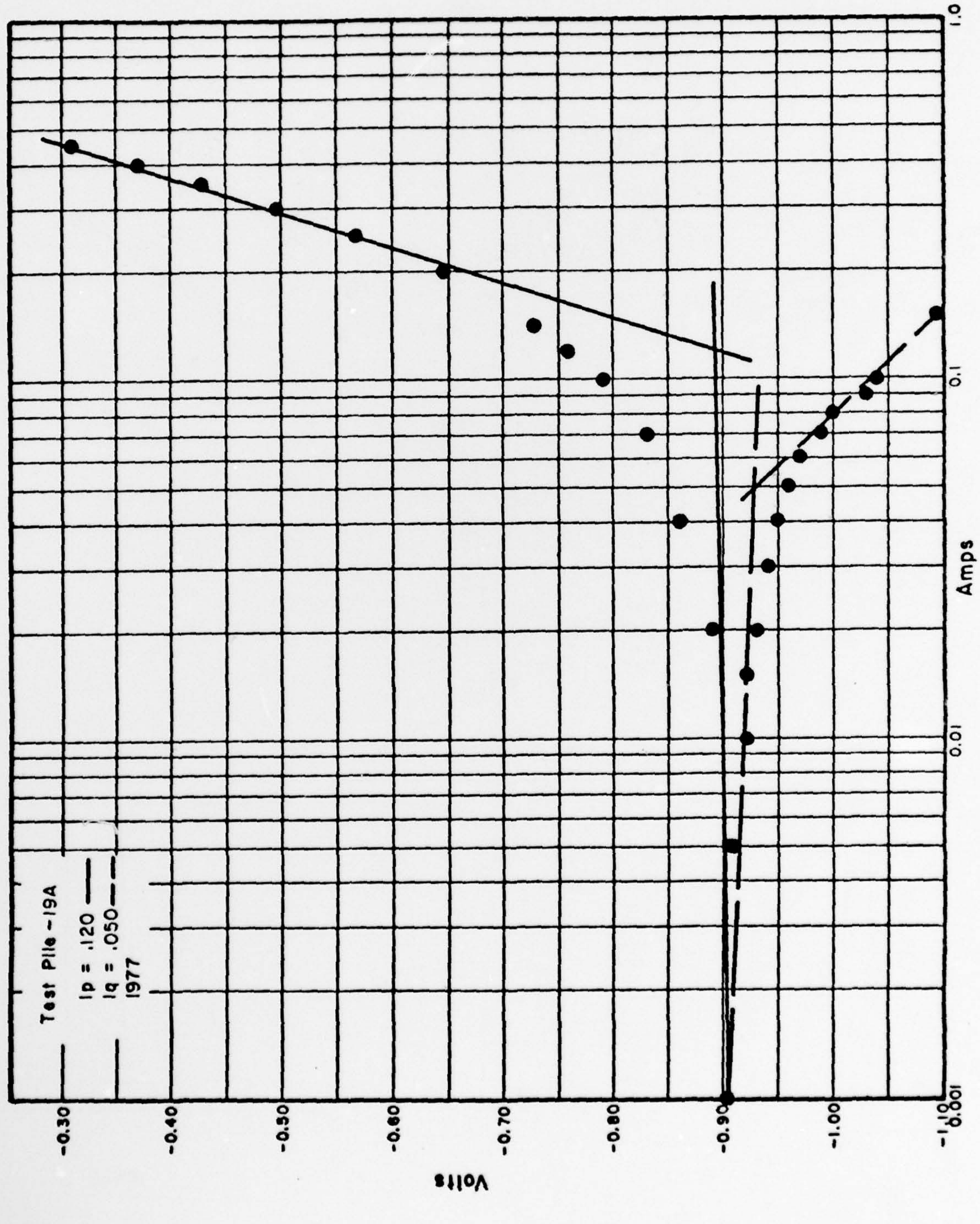

Test Pile - 18A
Ip = .058
Iq = .050
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0


Test Pile - 18A
Ip = .044
Iq = .052
1978
Volts
Amps
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

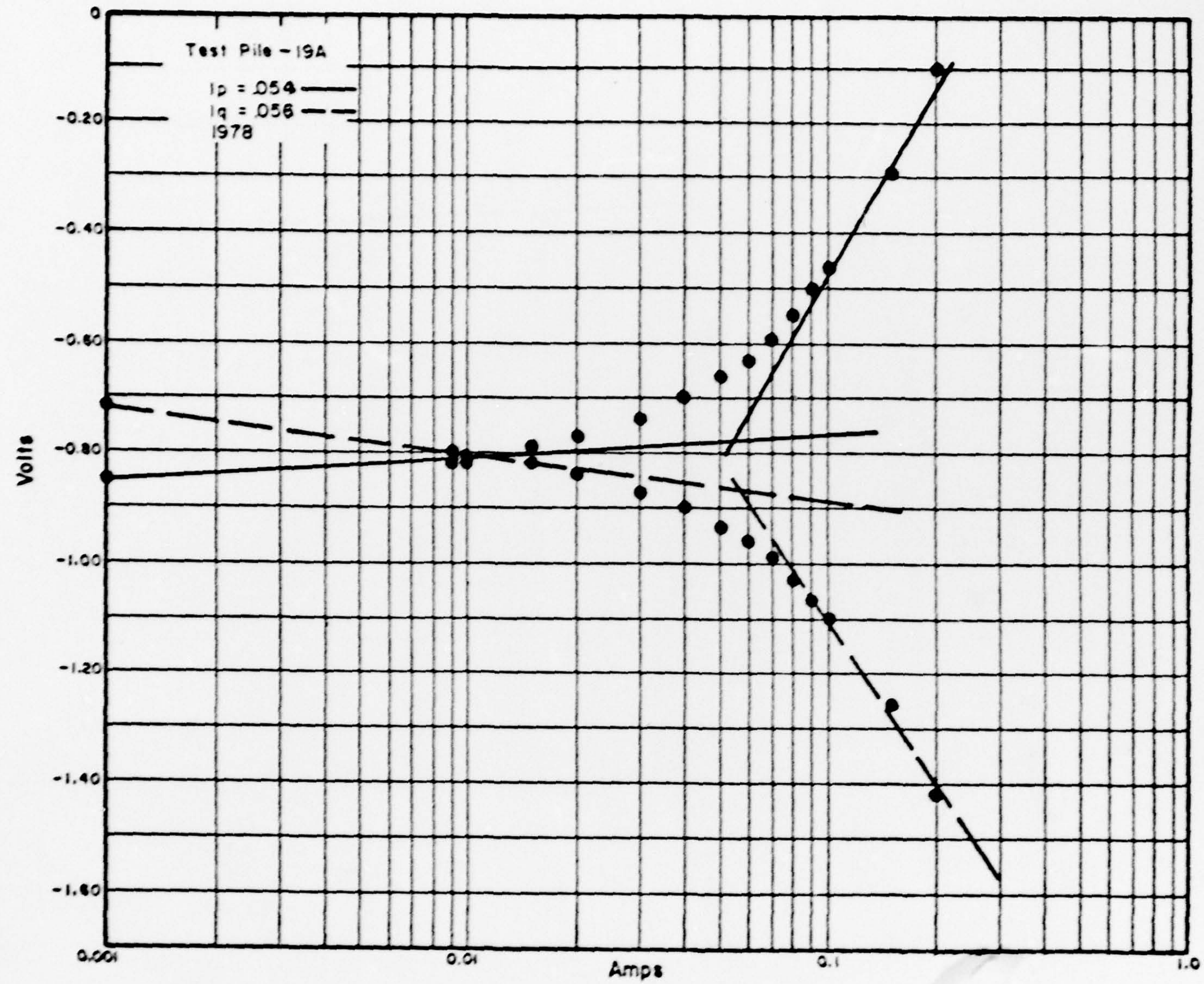

Test Pile-18B
Ip = .05
Iq = .028
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0

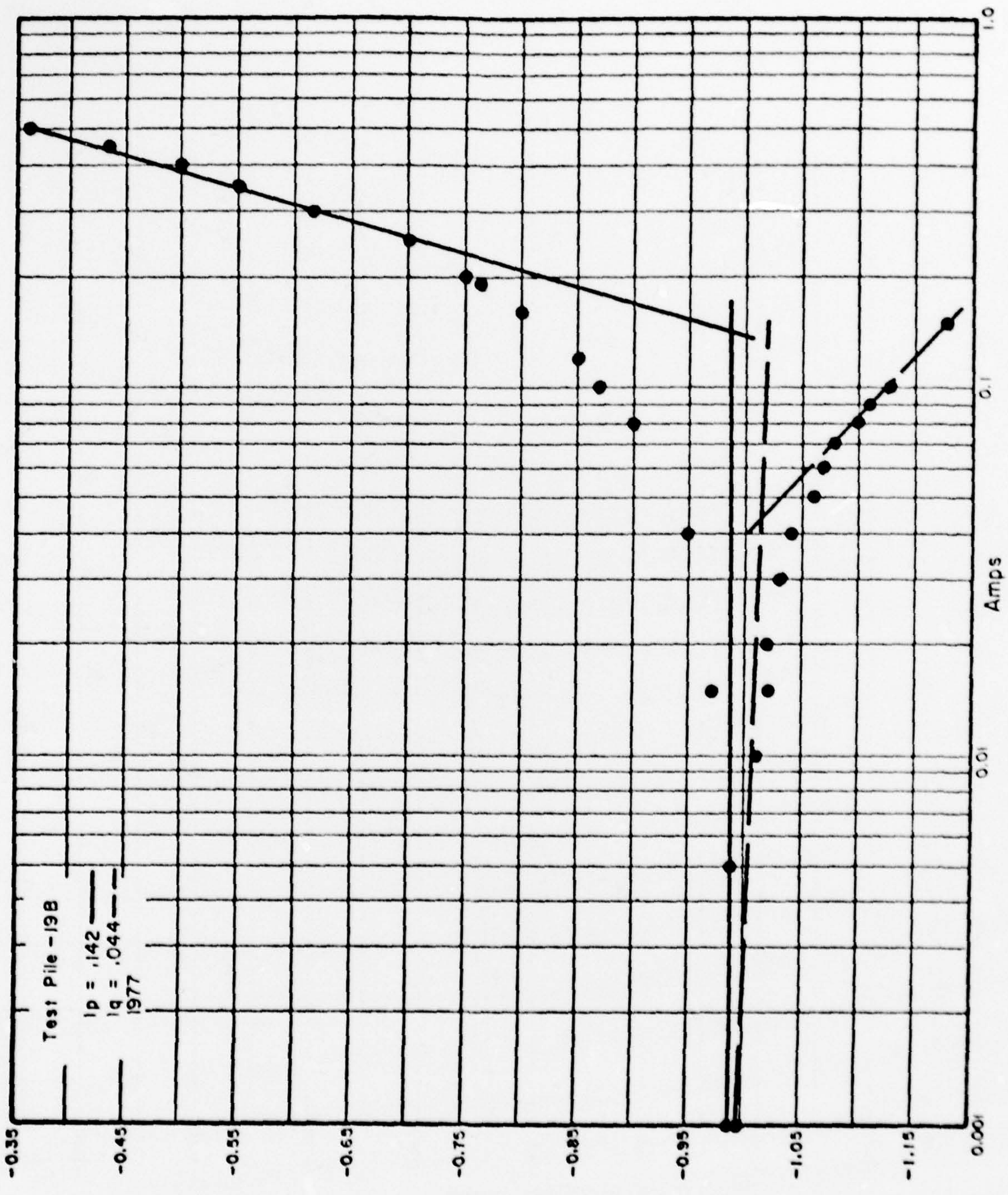

Test Pile - 18 B
Iq = .043
1978
Volts
Amps
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

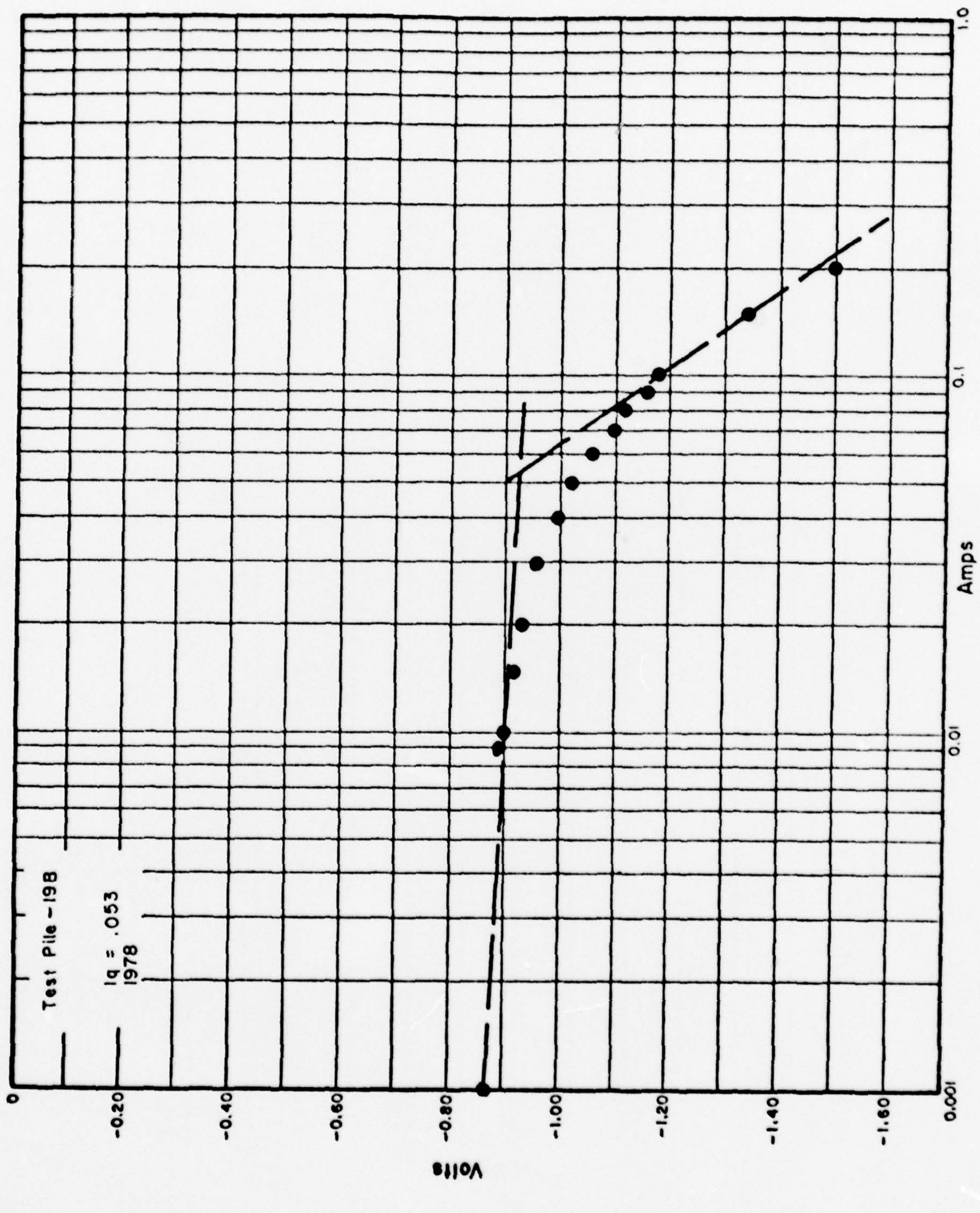

Test Pile - 18C
Iq = .050
1978
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Amps
0.001
0.01
0.1
1.0

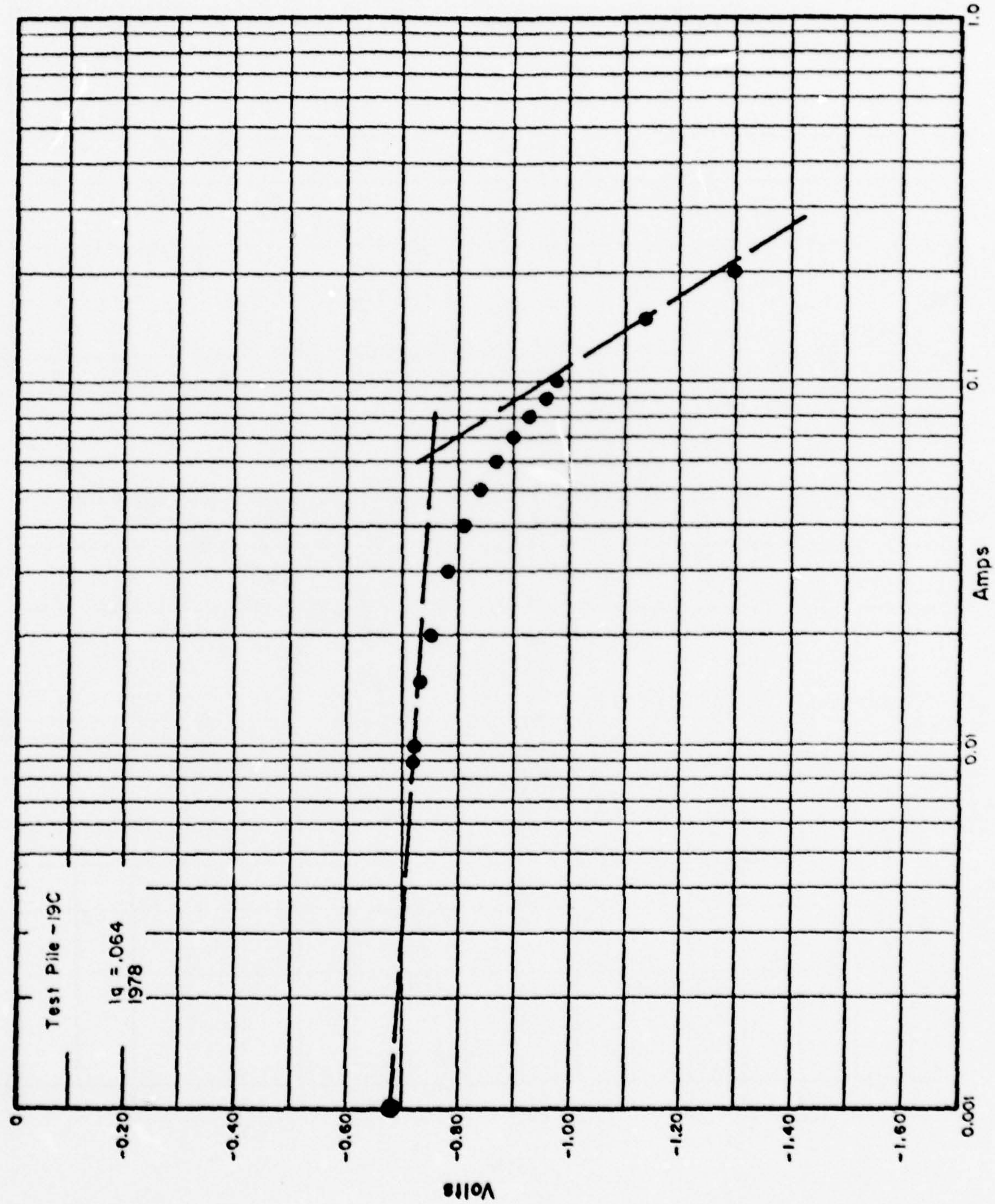


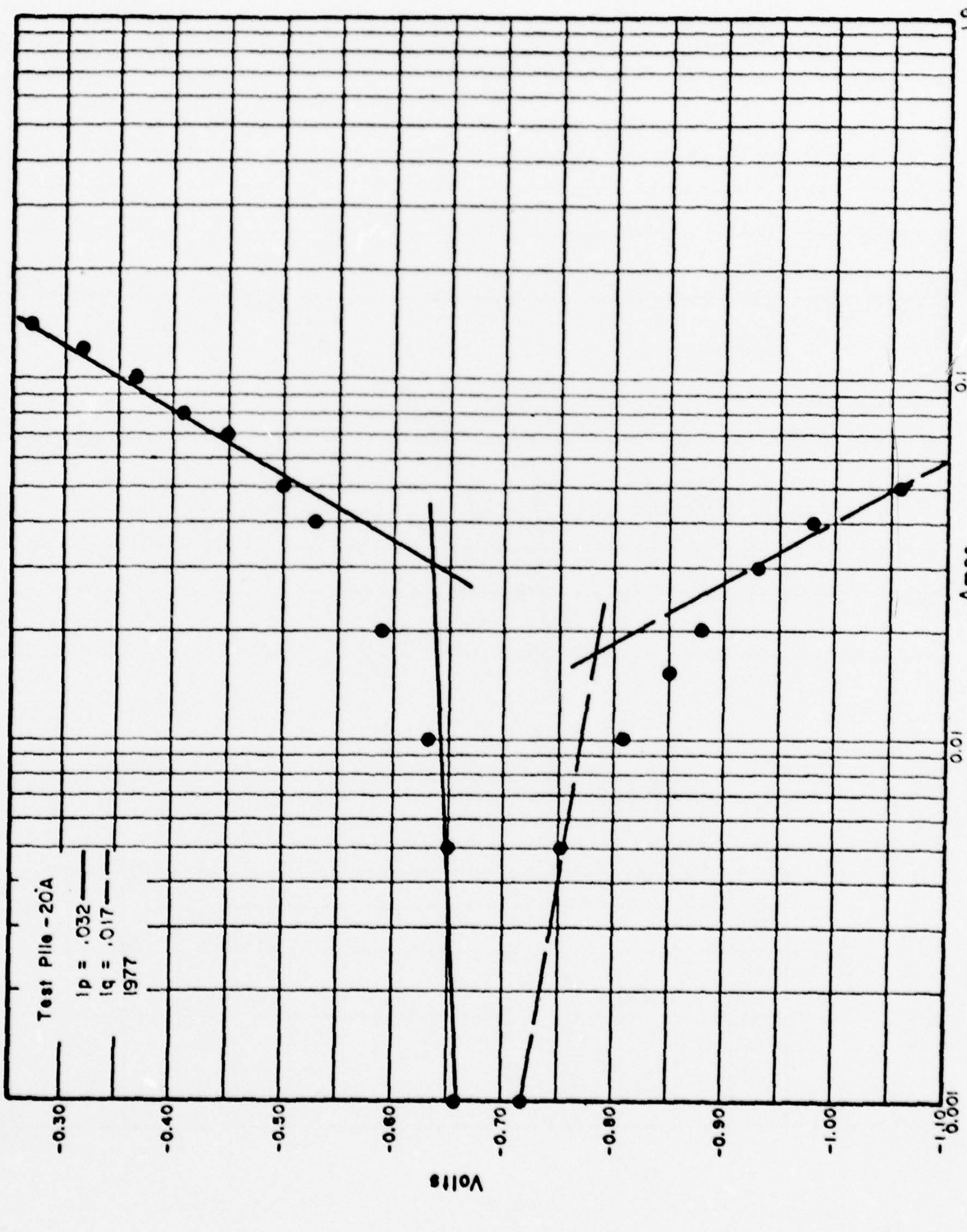
Test Pile - 19A
Ip = .120
Iq = .050
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0

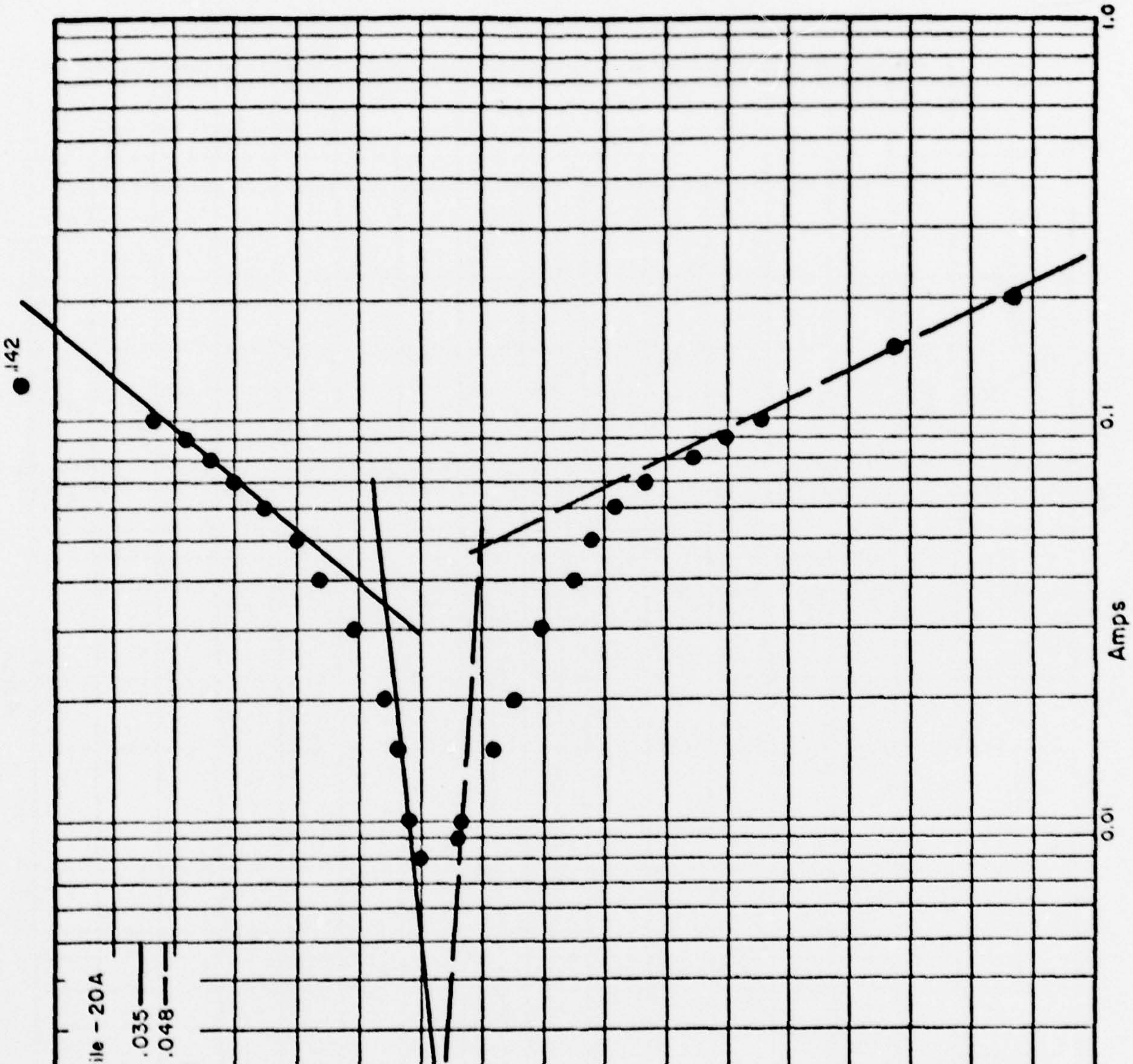

Test Pile - 19A
Ip = .054
Iq = .056
1978
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Amps
0.001
0.01
0.1
1.0


Test Pile - 19B
Ip = .142
Iq = .044
1977
Volts
-0.35
-0.45
-0.55
-0.65
-0.75
-0.85
-0.95
-1.05
-1.15
Amps
0.001
0.01
0.1
1.0

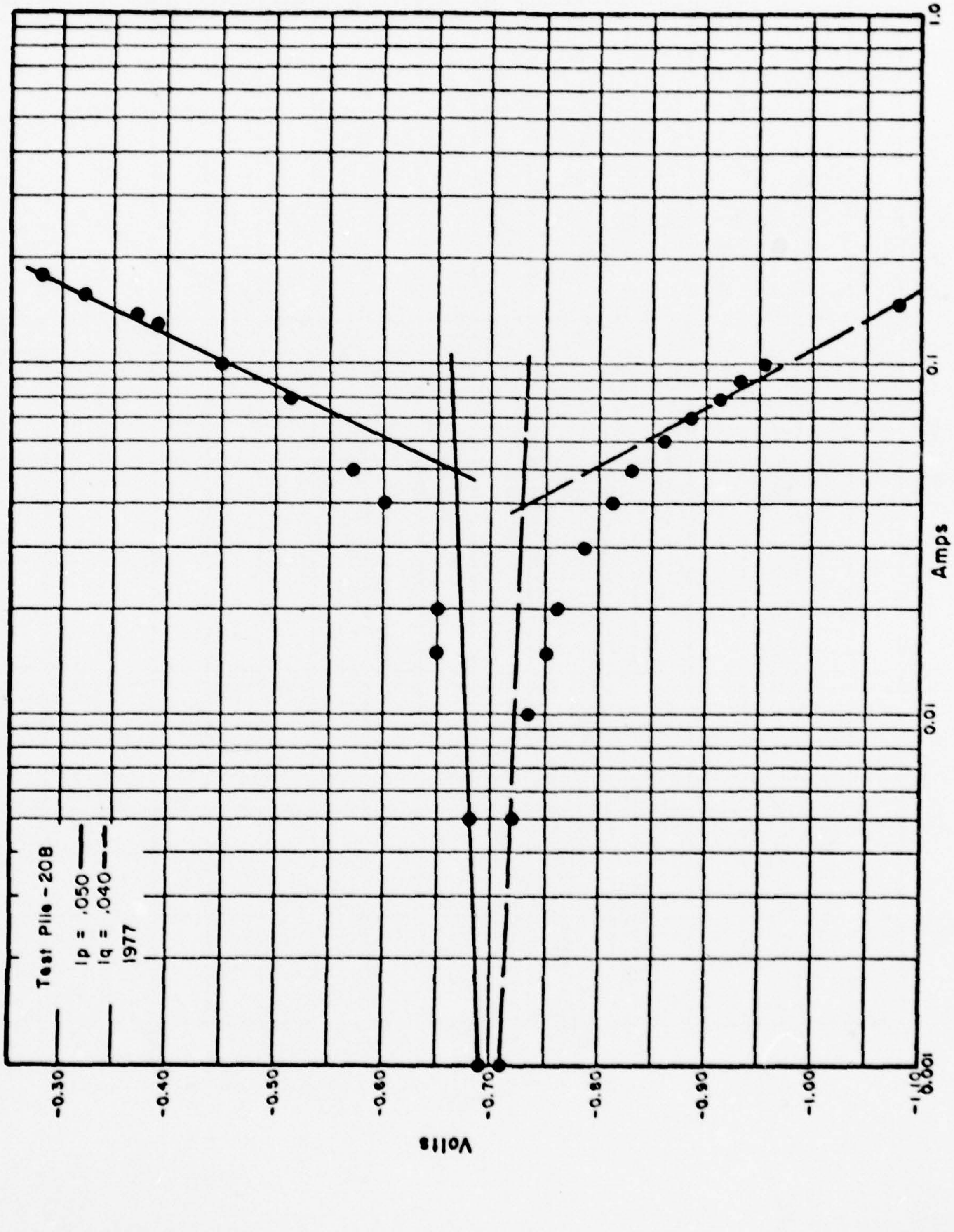

Test Pile - 19B
Iq = .053
1978
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Volts
0.001
0.01
0.1
1.0
Amps


Test Pile -19C
Iq = .064
1978
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Volts
0.001
0.01
0.1
1.0
Amps

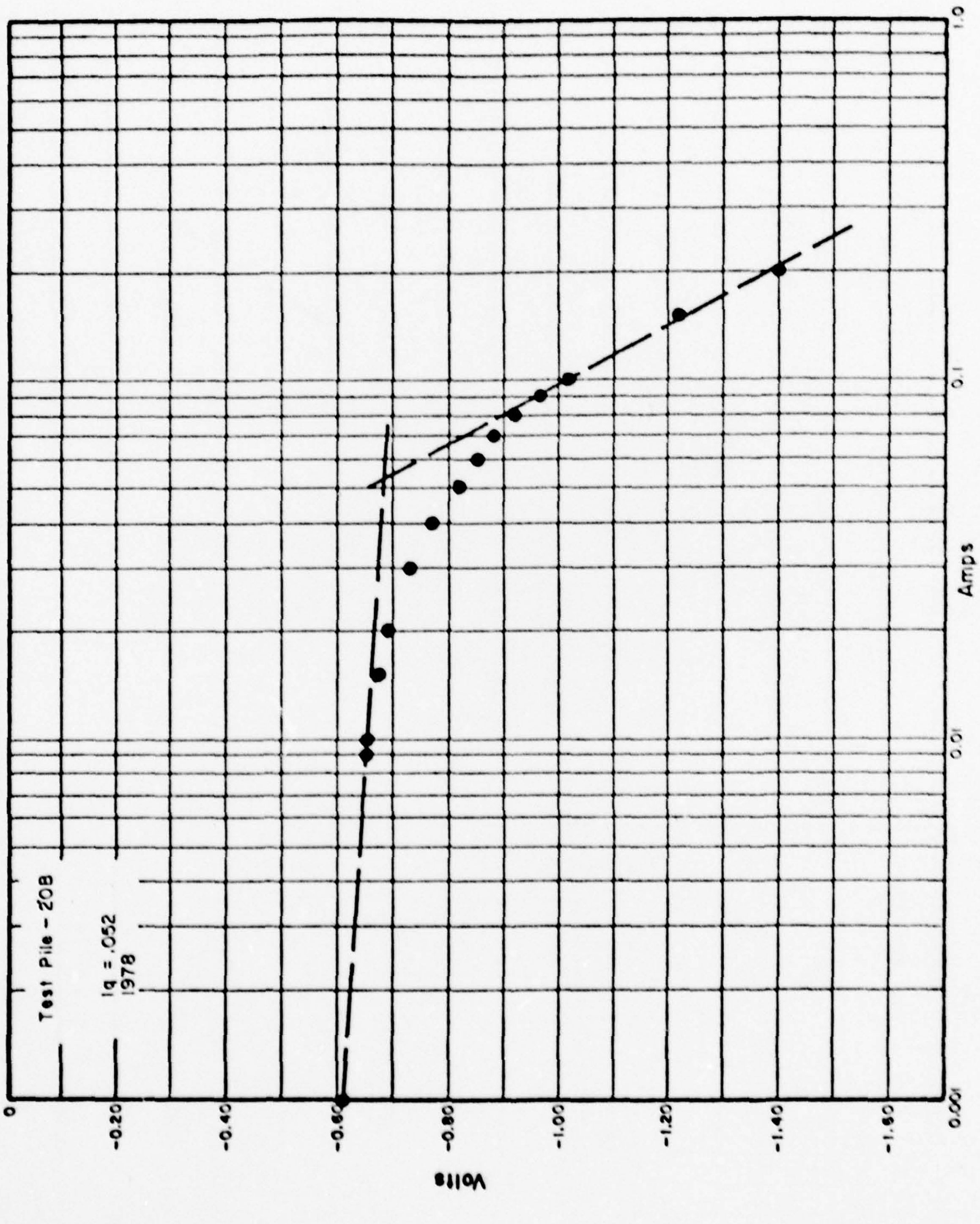

Test Pile - 20A
Ip = .032
Iq = .017
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0

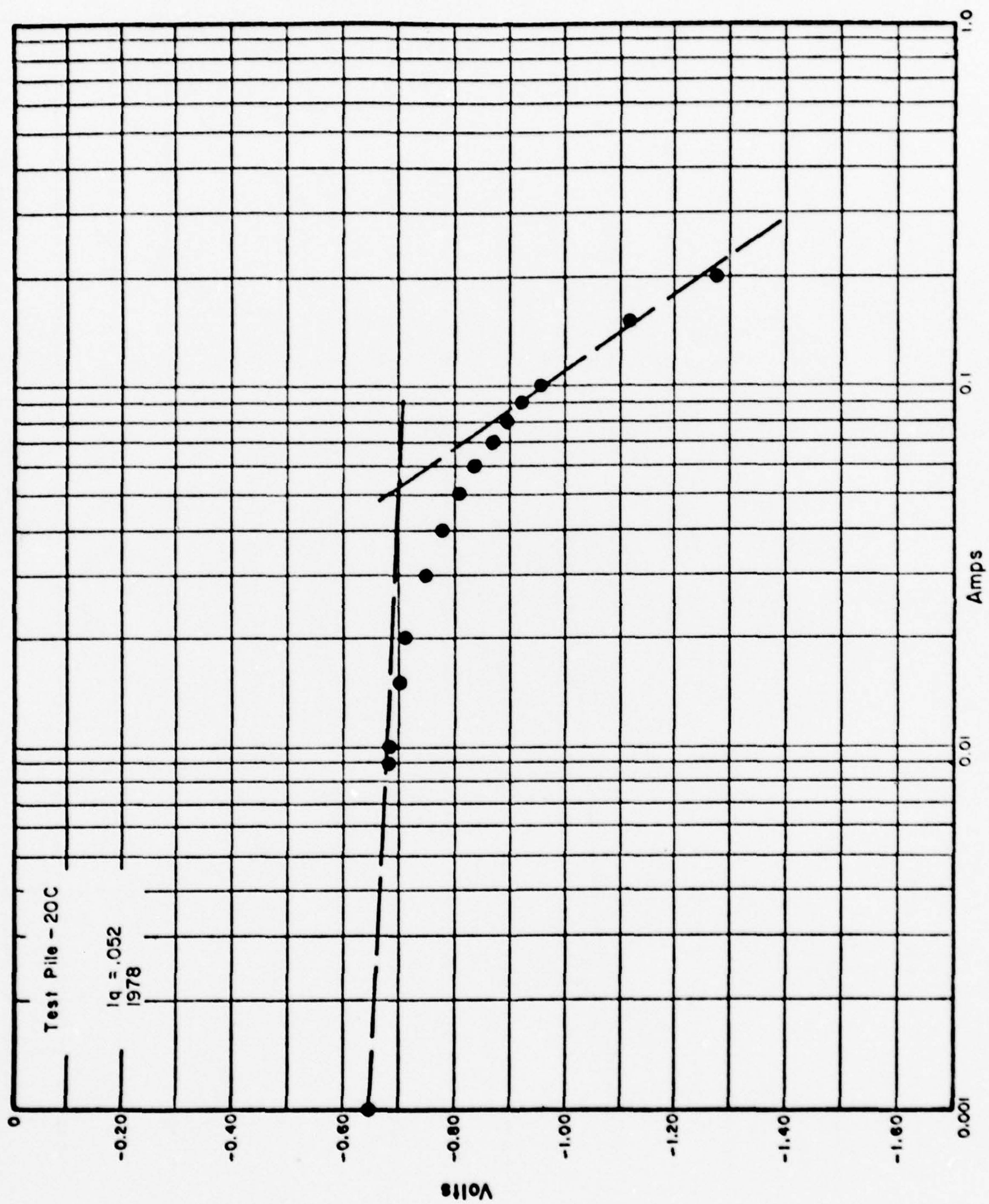


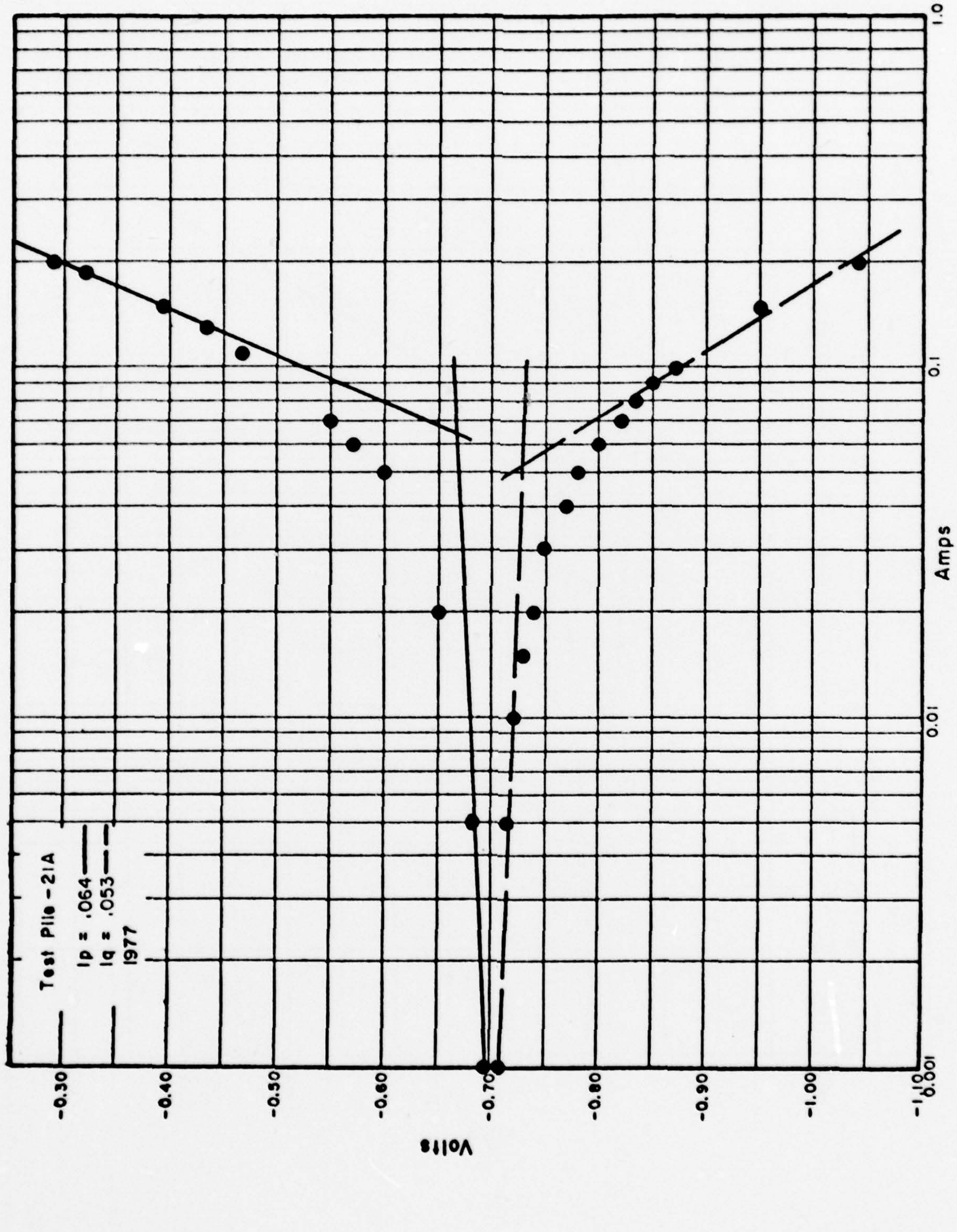
Test Pile - 20A
Ip = .035
Iq = .048
1978
.142
Volts
Amps
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0

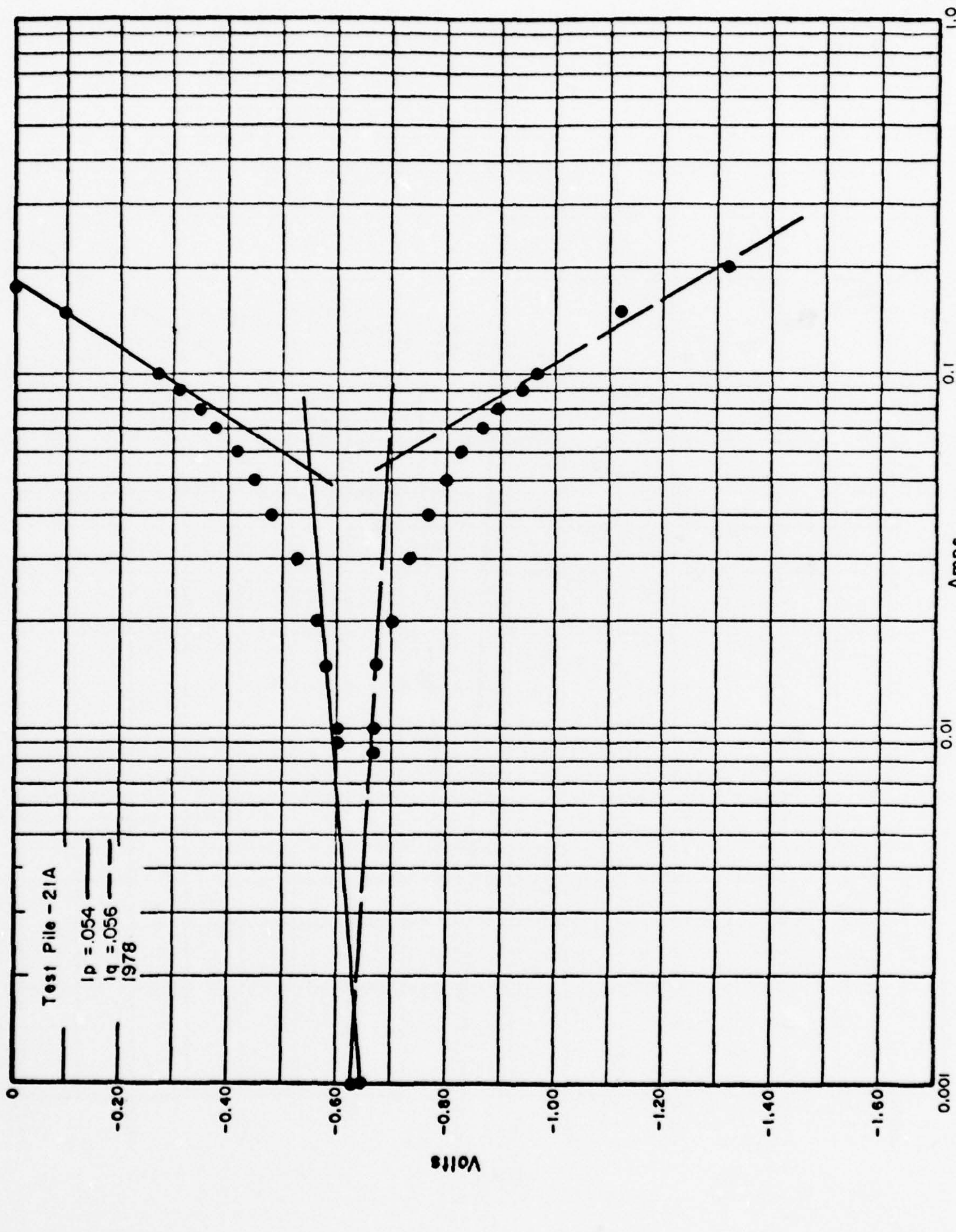


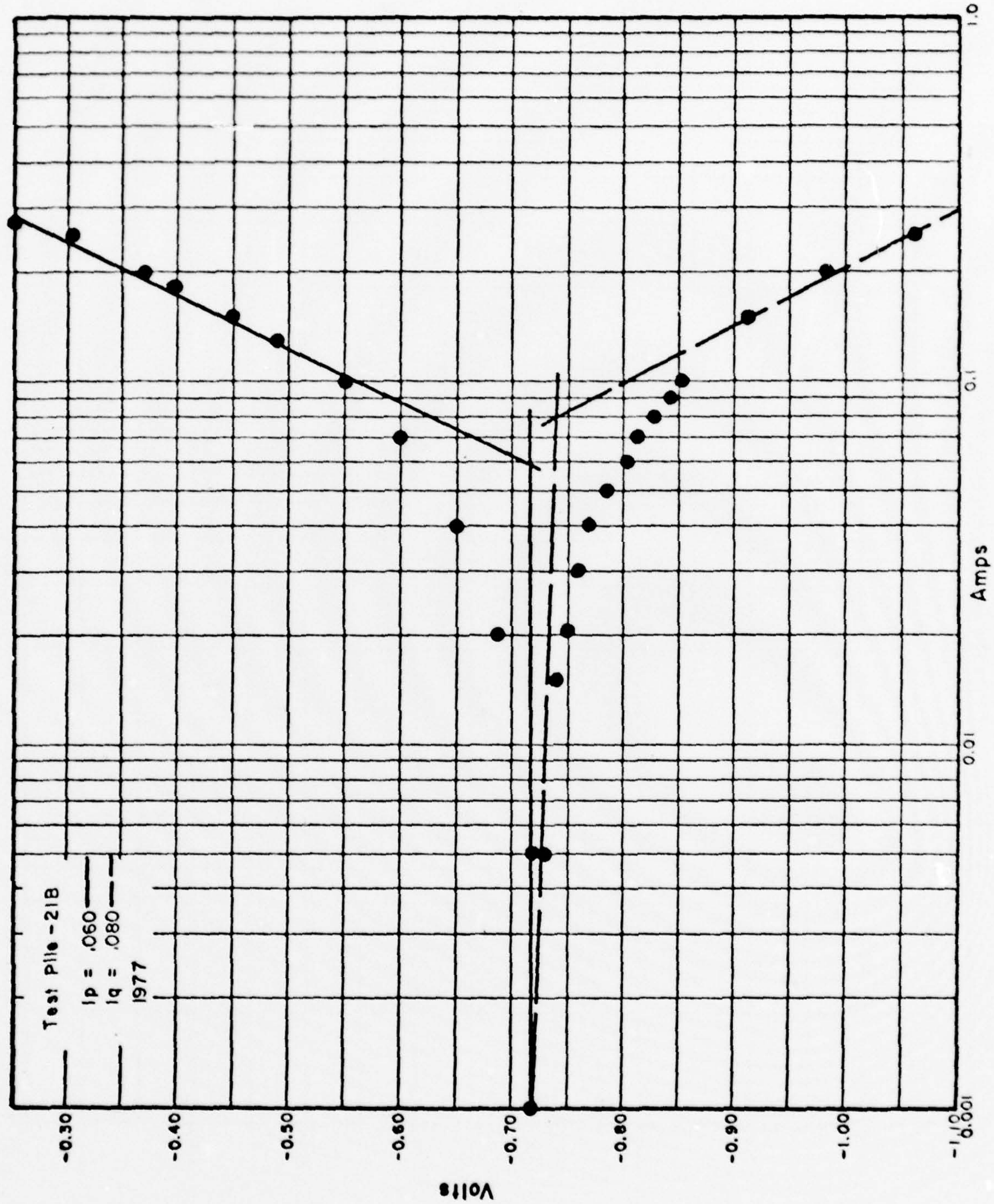
Test Pile - 20B
Ip = .050
Iq = .040
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0

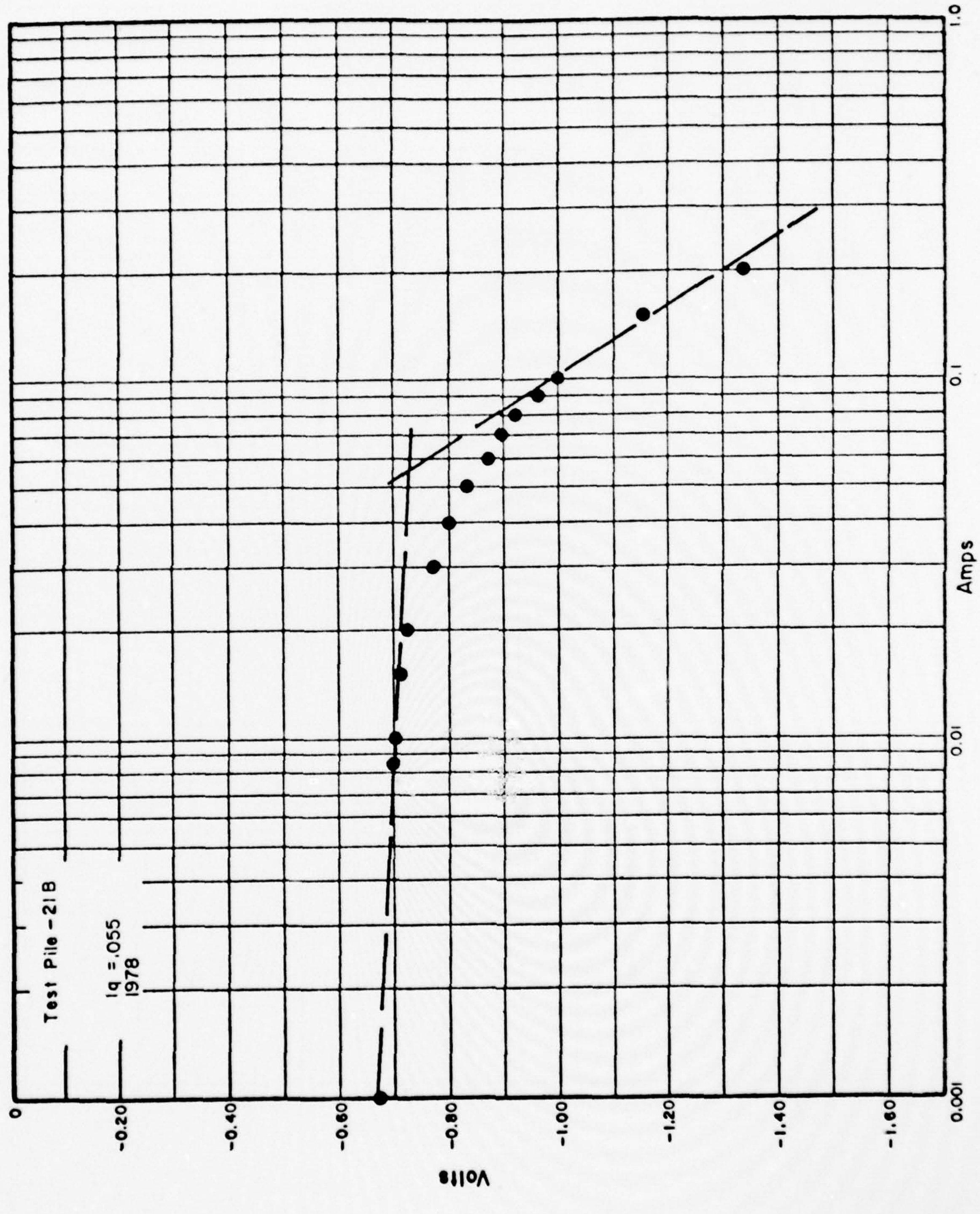

Test Pile - 20B
Iq = .052
1978
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Amps
0.001
0.01
0.1
1.0

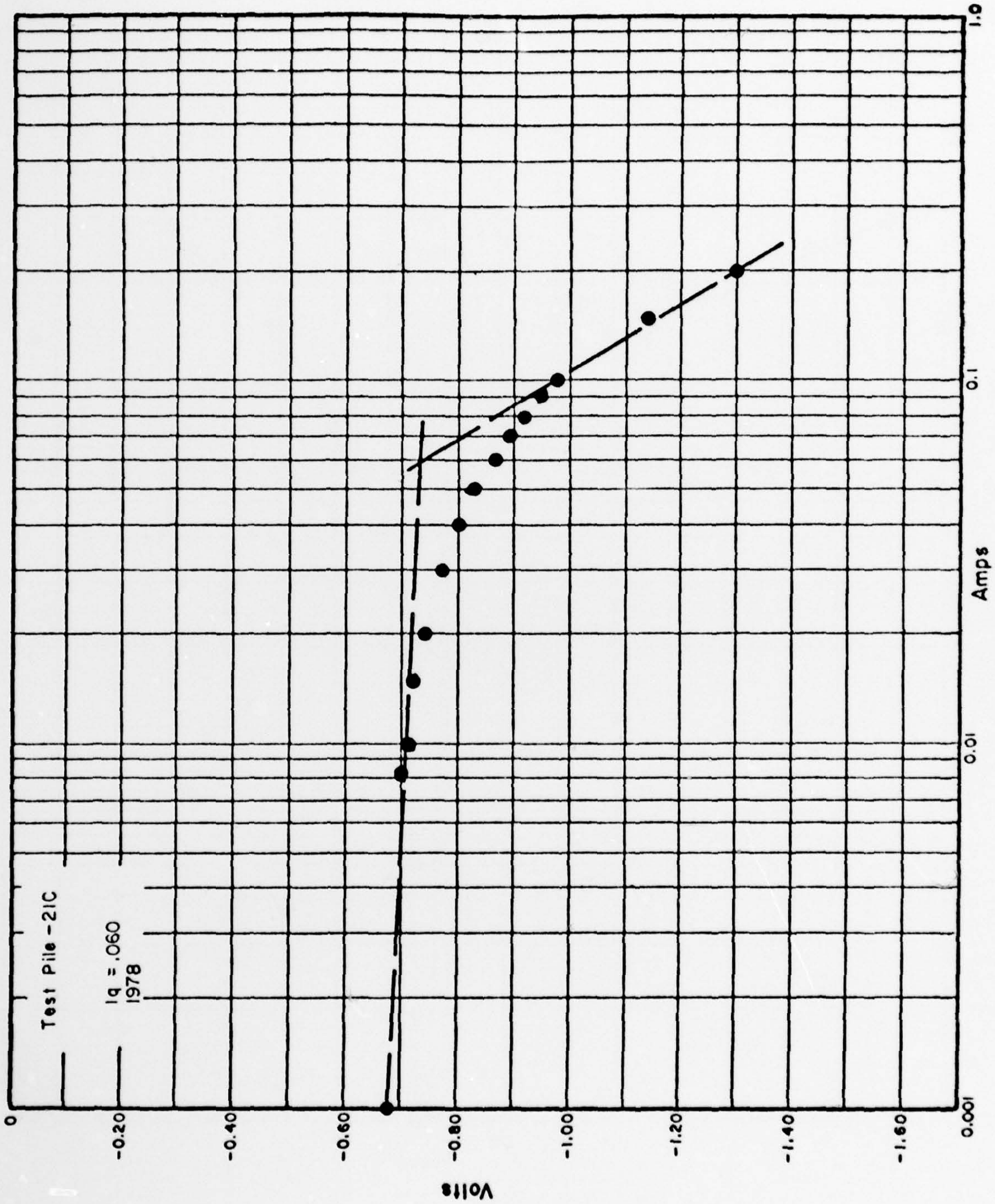

Test Pile - 20C
Iq = .052
1978
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Amps
0.001
0.01
0.1
1.0


Test Pile - 21A
Ip = .064
Iq = .053
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0

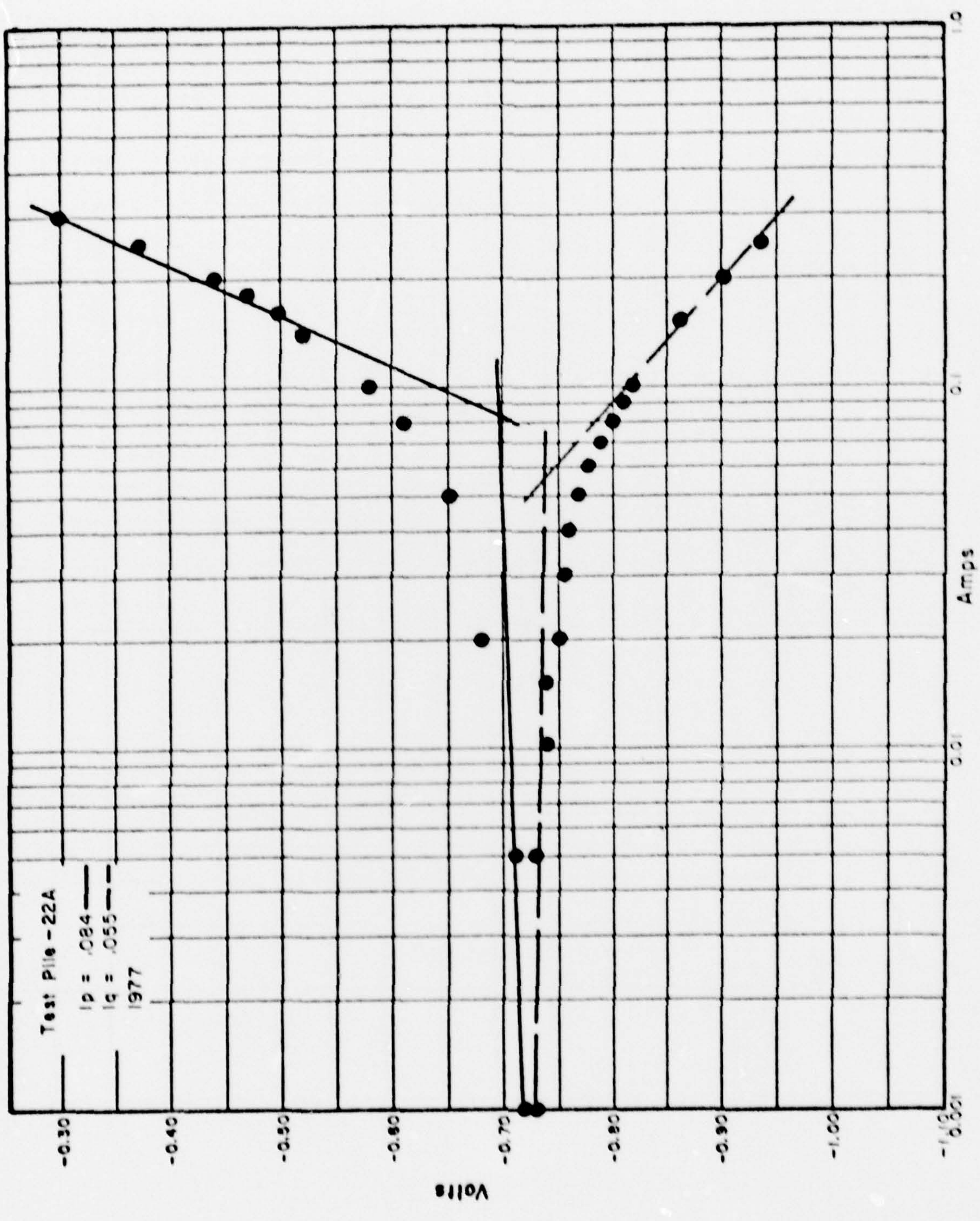

Test Pile - 21A
Ip =.054
Iq =.056
1978
Volts
Amps
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
0.001
0.01
0.1
1.0


Test Pile -21B
Ip = .060
Iq = .080
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0

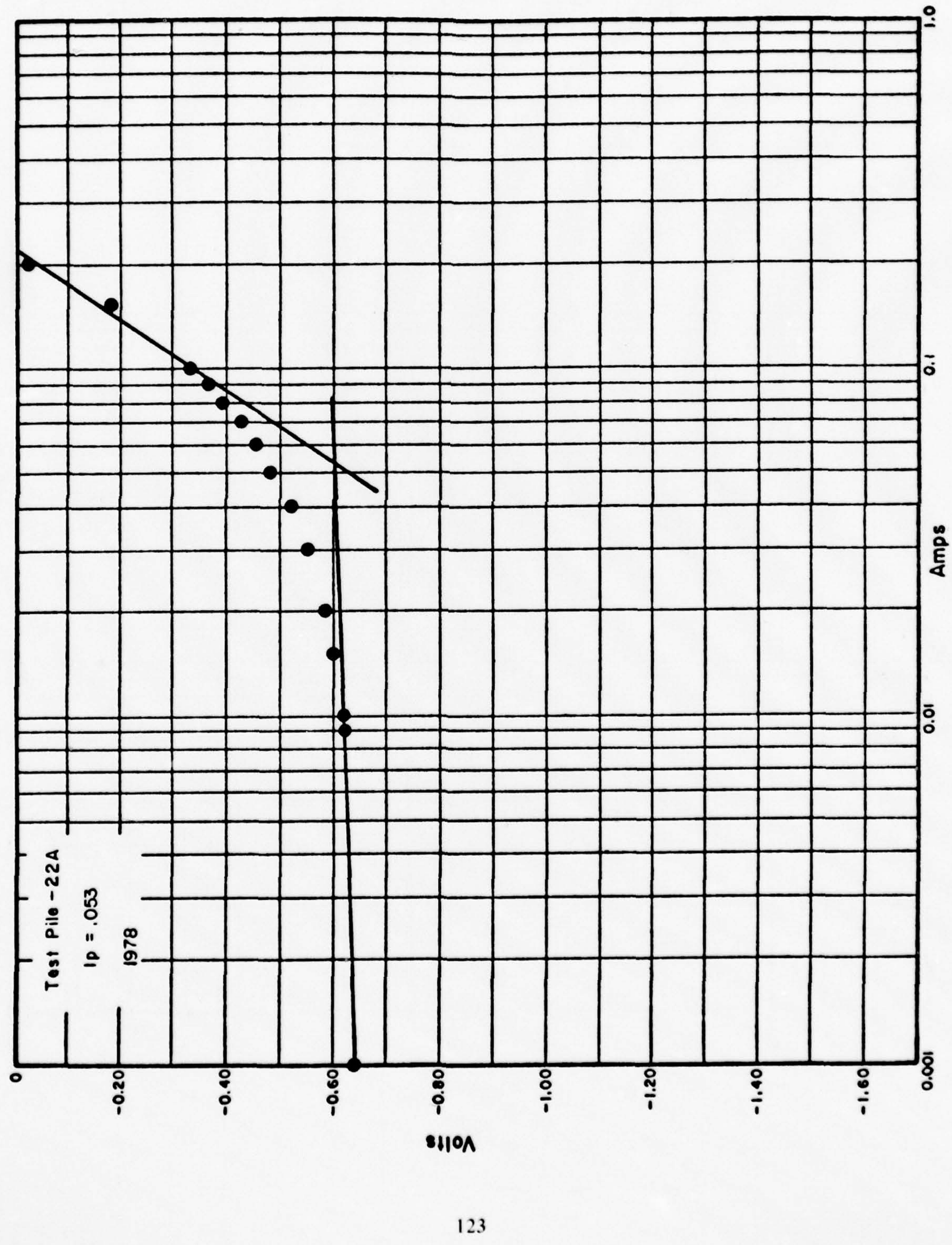

Test Pile -21B
Iq =.055
1978
Amps
0.001
0.01
0.1
1.0
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60

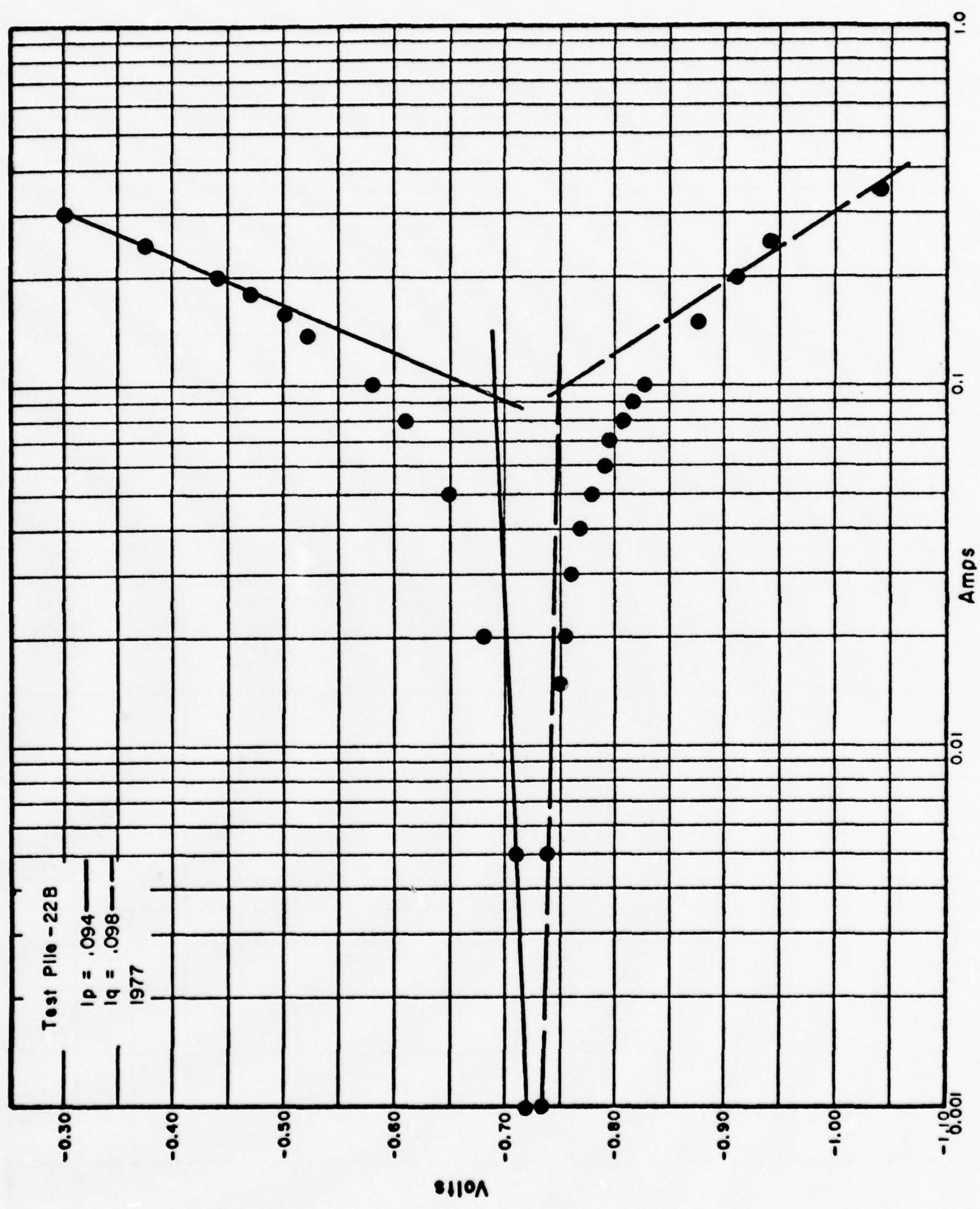


Test Pile -21C
Iq =.060
1978
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Amps
0.001
0.01
0.1
1.0

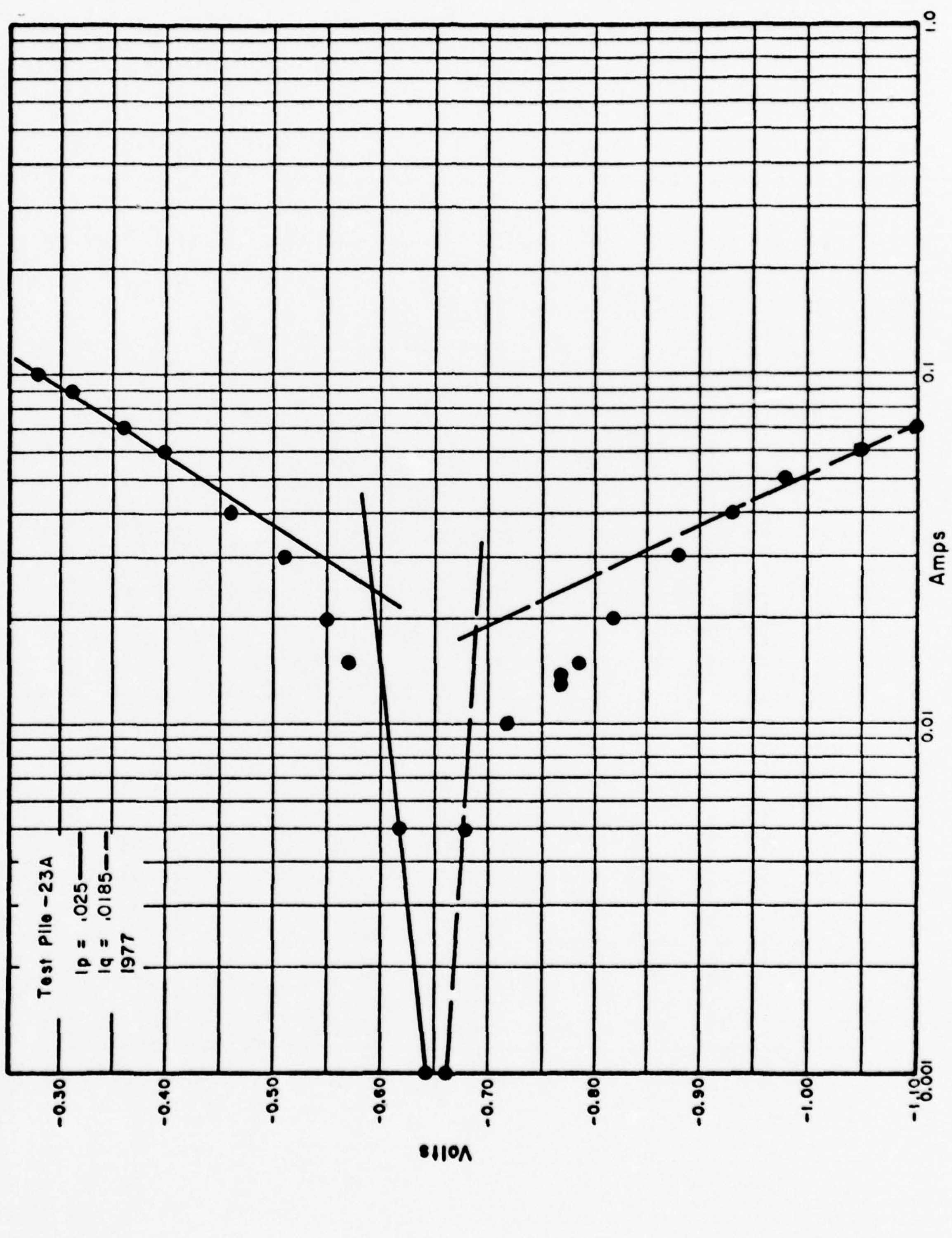


Test Pile - 22A
Ip = .084
Iq = .055
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0

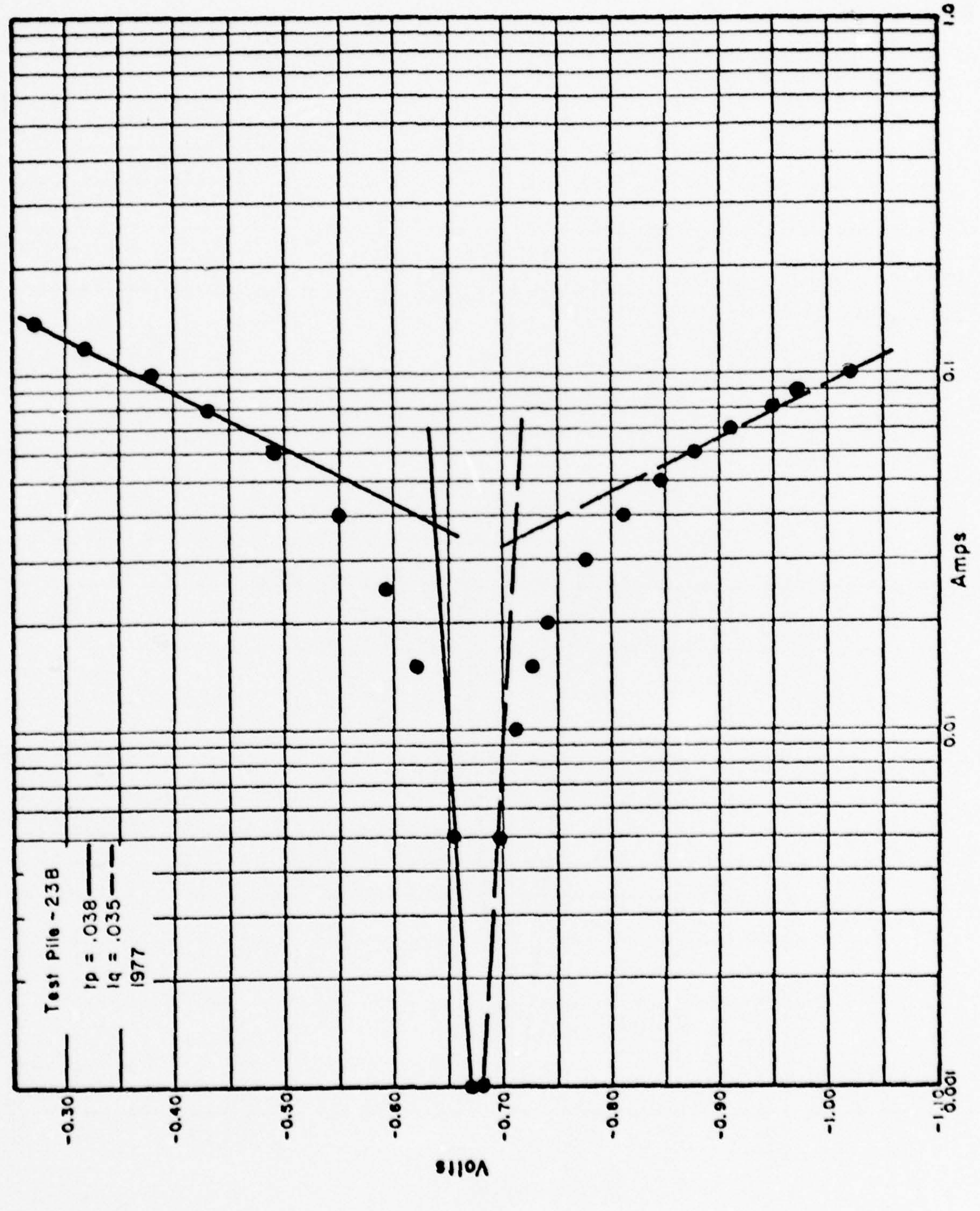

Test Pile - 22A
Ip = .053
1978
Amps
Volts
0.001
0.01
0.1
1.0
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60



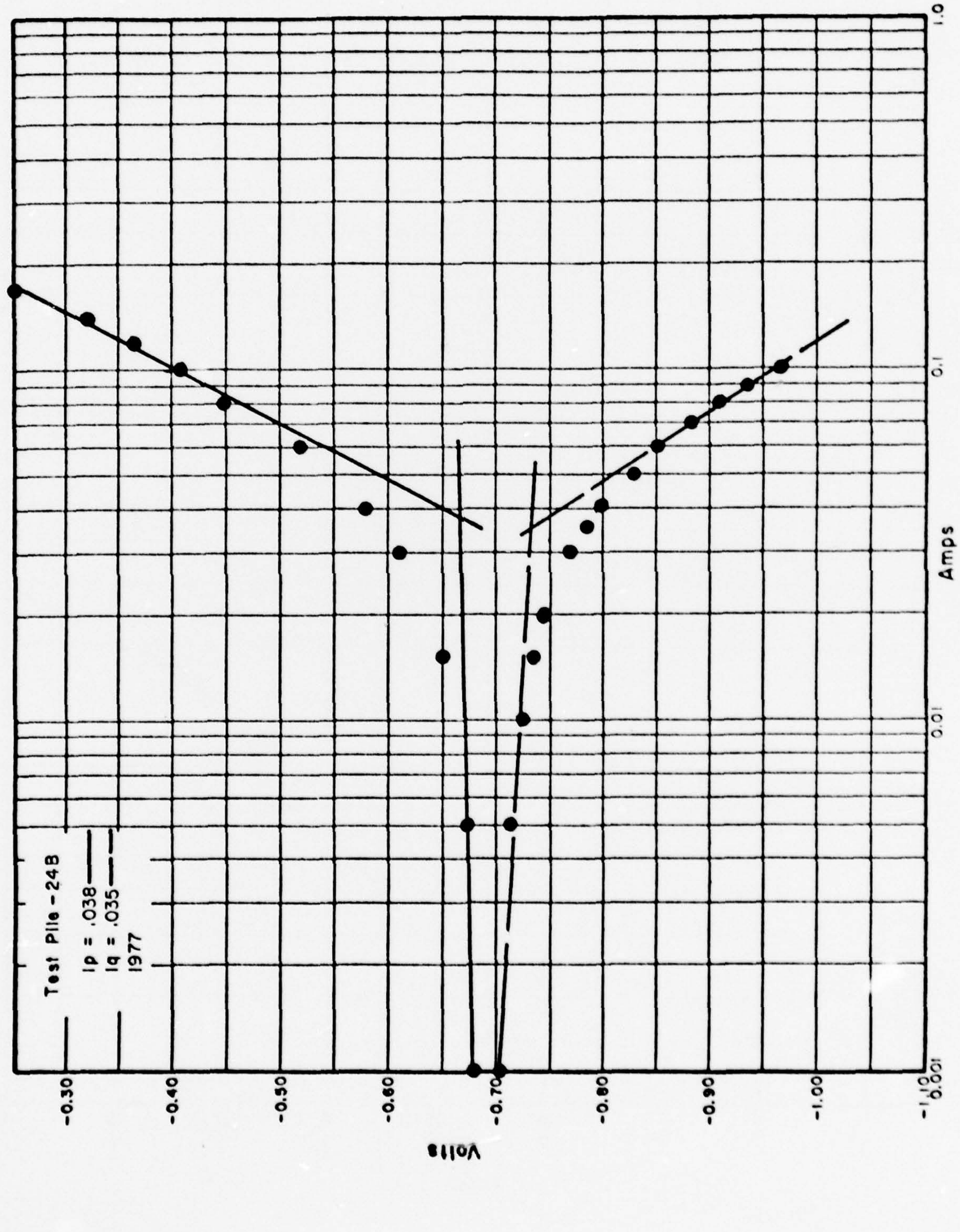
Test Pile - 22B
Ip = .094
Iq = .098
1977
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Volts
0.001
0.01
0.1
1.0
Amps

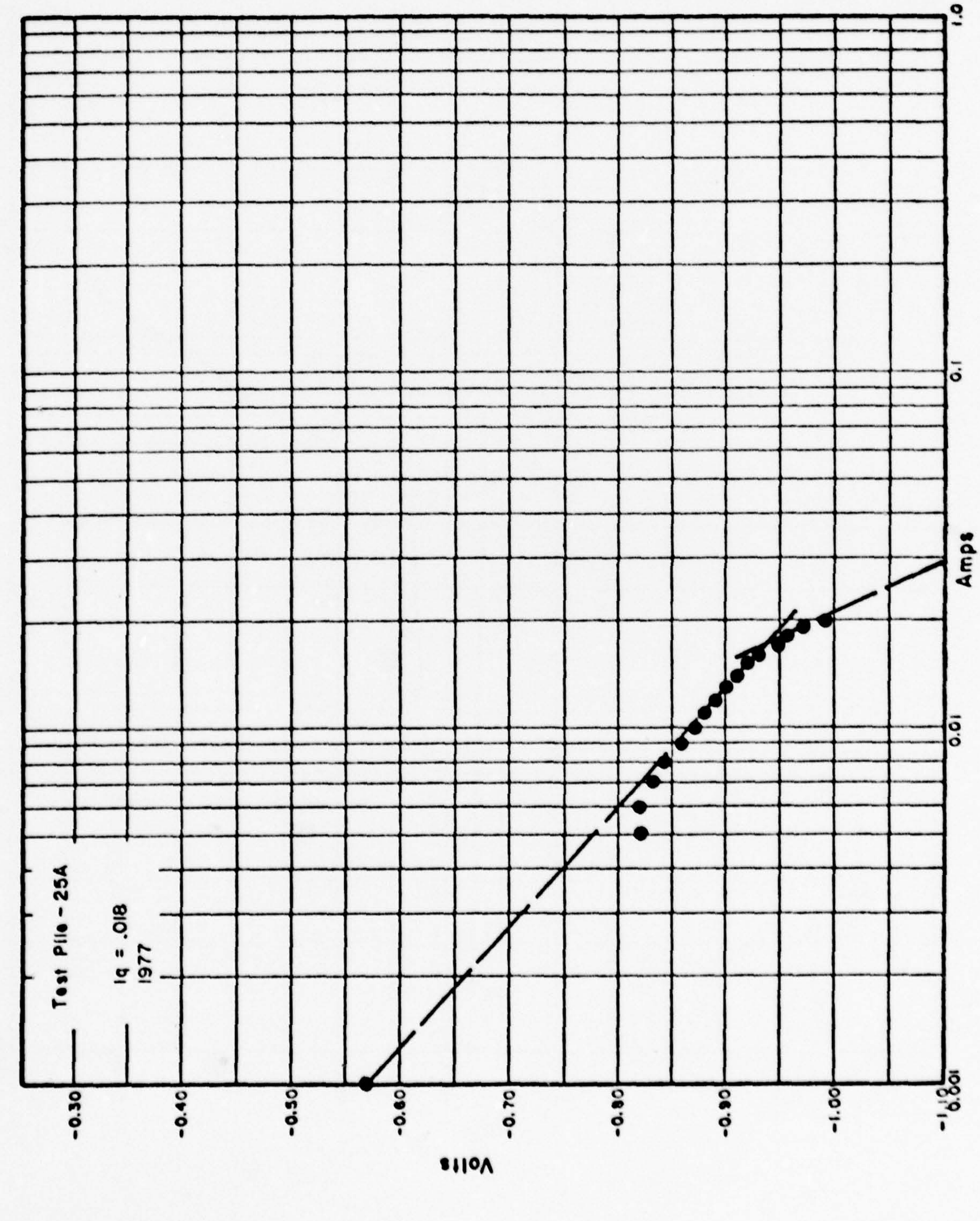


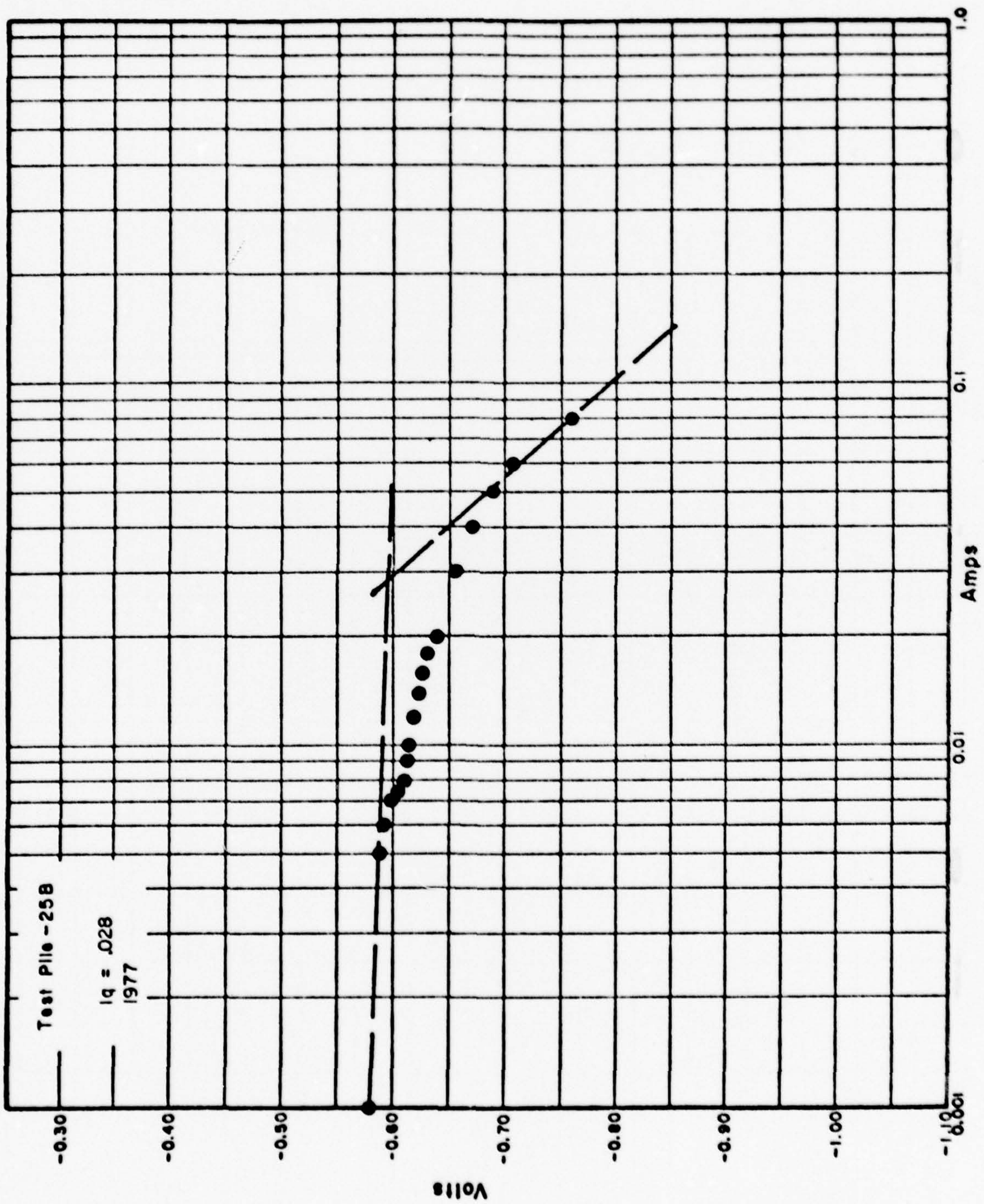
Test Pile-23A
Ip = .025
Iq = .0185
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0

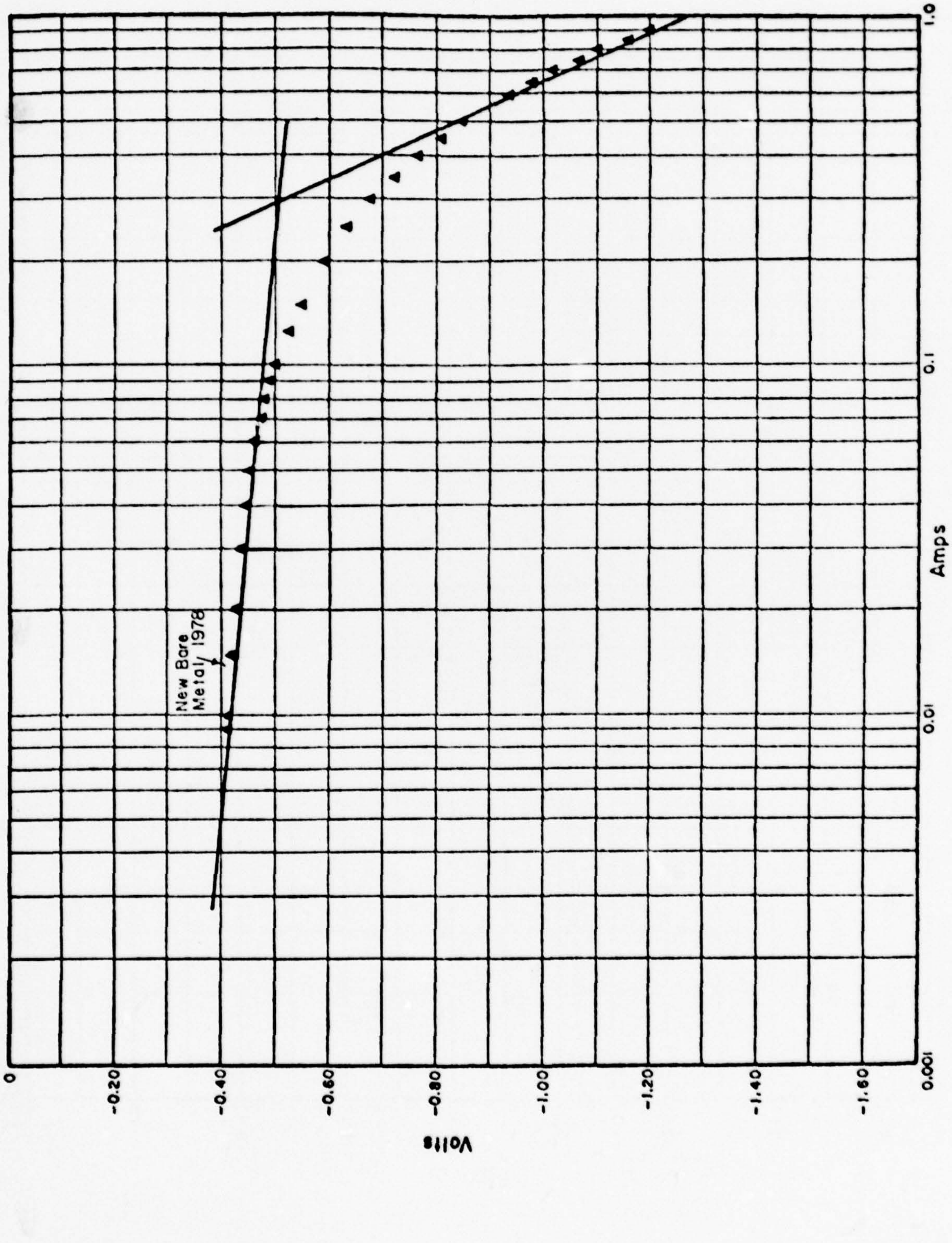


Test Pile - 23B
Ip = .038
Iq = .035
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0


Test Pile - 24B
Ip = .038
Iq = .035
1977
Volts
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Amps
0.001
0.01
0.1
1.0


Test Pile - 25A
Iq = .018
1977
Volts
Amps
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
0.001
0.01
0.1
1.0


Test Pile -25B
Iq = .028
1977
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
Volts
0.001
0.01
0.1
1.0
Amps



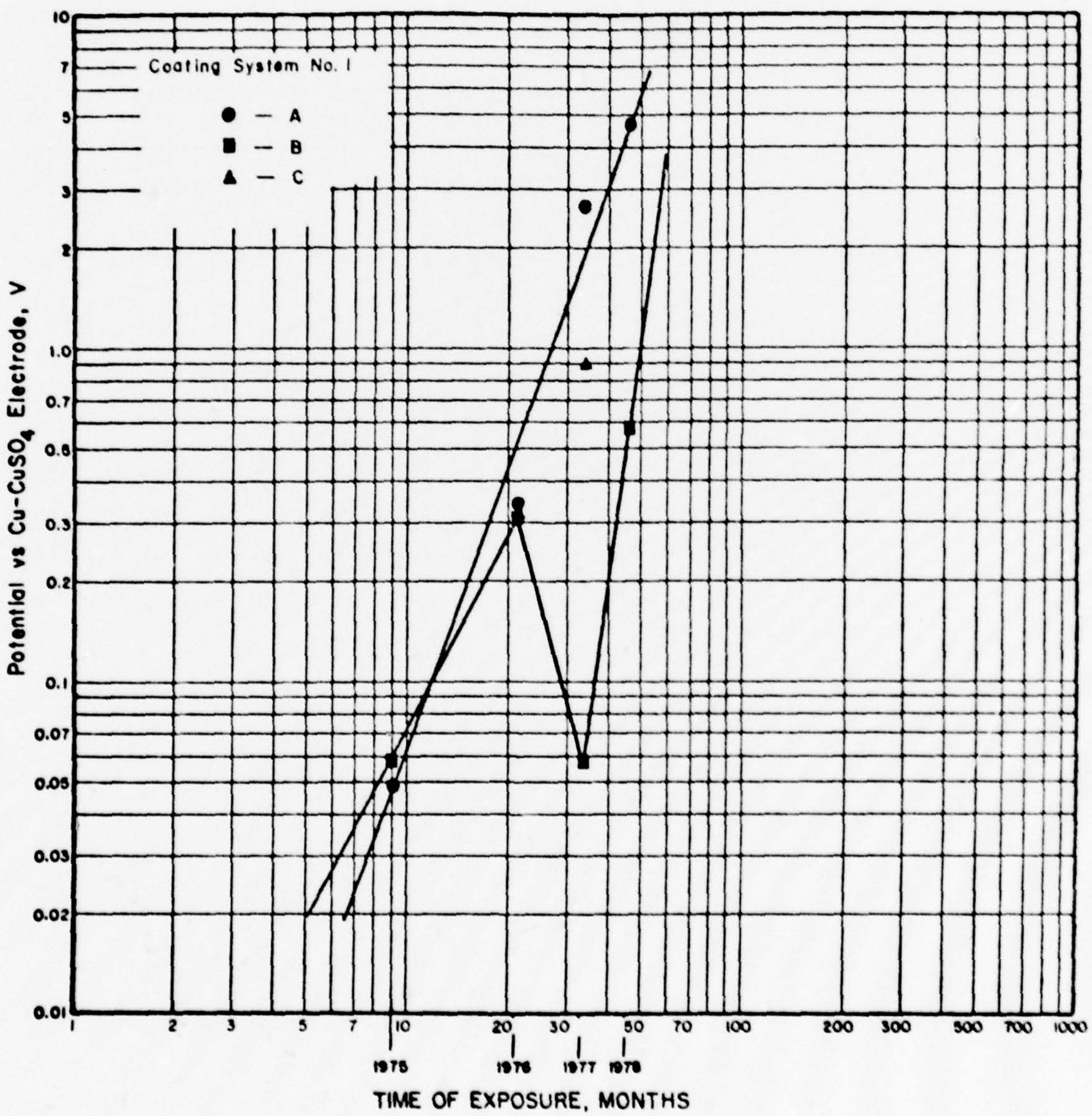
Volts
0
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
Amps
0.001
0.01
0.1
1.0
New Bare Metal 1978

APPENDIX B: CATHODIC PROTECTION INDICES

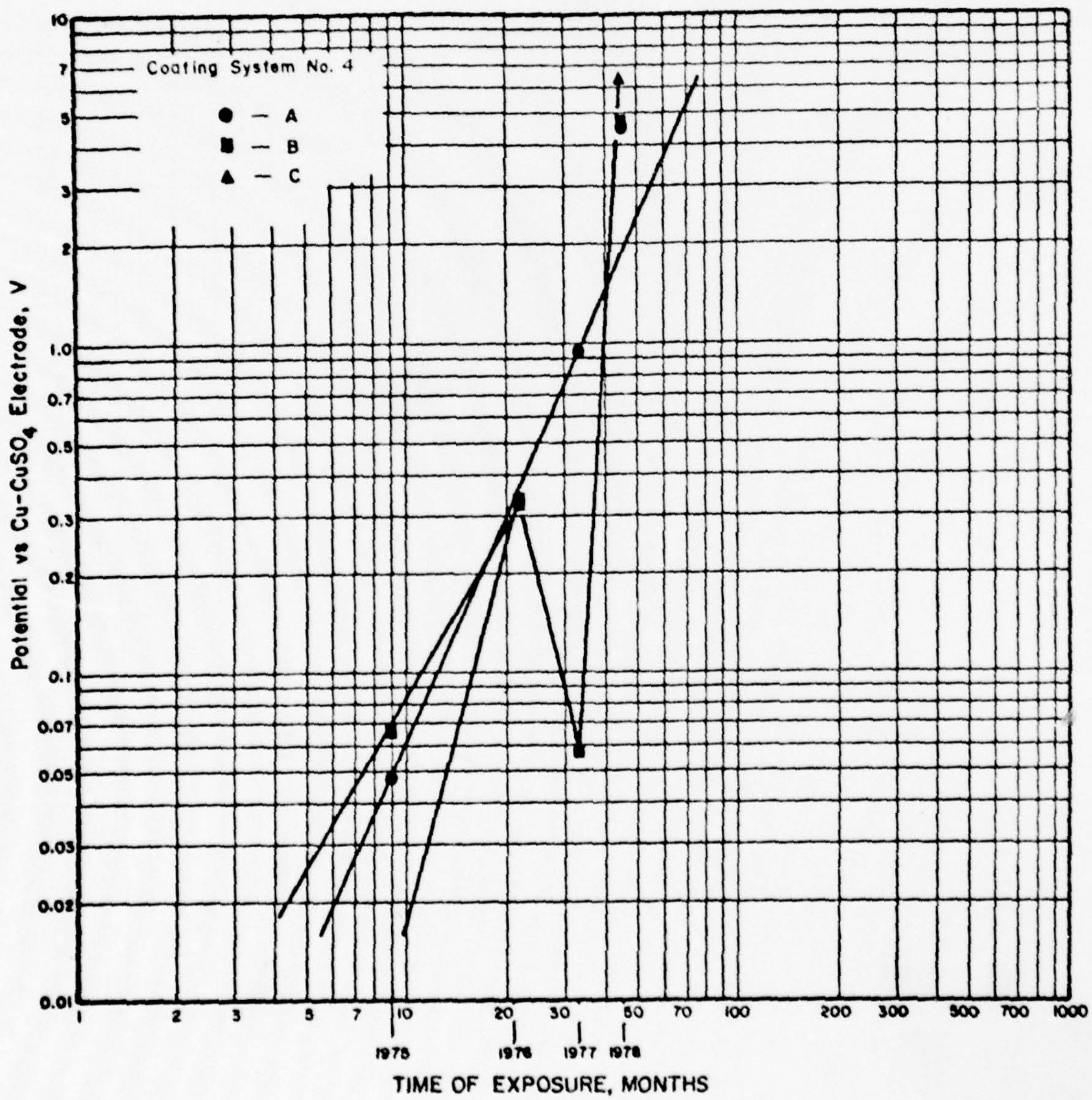
Pile No.	1975	1976	1977	1978
1A	0.0487	0.333	2.78	4.6
B	0.058	0.327	0.058	5.86
C	Aux	Aux	0.89	Aux
4A	0.0472	0.34	0.87	2.52
B	0.0667	0.34	0.058	4.69
C	–	0.321	Aux	6.25
7A	7.65	14.29	11.00	10.38
B	6.21	4.52	6.11	
C	0.19	0.449	1.47	
8A	7.19	14.29	7.50	
B	7.20	2.75	1.96	7.65
C	0.18	0.435	1.62	4.44
9A	6.13	14.29	7.69	6.88
B	7.50	6.38	1.69	7.13
C	0.18	0.459	1.75	5.0
10A	6.0	12.09	3.85	8.92
B	16.16	6.1	3.57	6.5
C	0.19	0.438	1.58	4.38
11A	5.33	12.5	7.50	10.0
B	8.70	4.21	1.85	6.43
C	0.16	0.44	1.57	5.0
12A	*	2.73	1.82	5.2
B	*	1.25	0.213	5.2
C	0.16	0.409	1.48	4.8
13A	5.68	14.29	4.14	7.37
B	15.15	2.65	1.20	6.08
C	0.15	0.458	1.55	4.7
14A	7.65	20.0	2.08	5.56
B	15.18	3.25	0.773	6.0
C	0.17	0.455	1.52	4.79
15A	7.22	11.04	17.86	20.0
B	13.71	2.73	1.53	6.52
C	0.71	0.44	1.49	4.64
16A	*	*	2.34	*
B	*	*	0.556	*
C	0.16	*	1.18	4.5
17A	*	0.669	1.65	*
B	*	*	0.30	*
C	0.15	0.397	1.47	3.04
18A	1.61	*	1.92	*
B	*	1.11	1.19	*
C	0.16	0.484	1.47	4.35
19A	*	*	1.79	*
B	*	*	0.375	*
C	*	*	1.43	5.88

*Initial Potential Reading <-0.85V (Potential not shifted 150mV more negative)

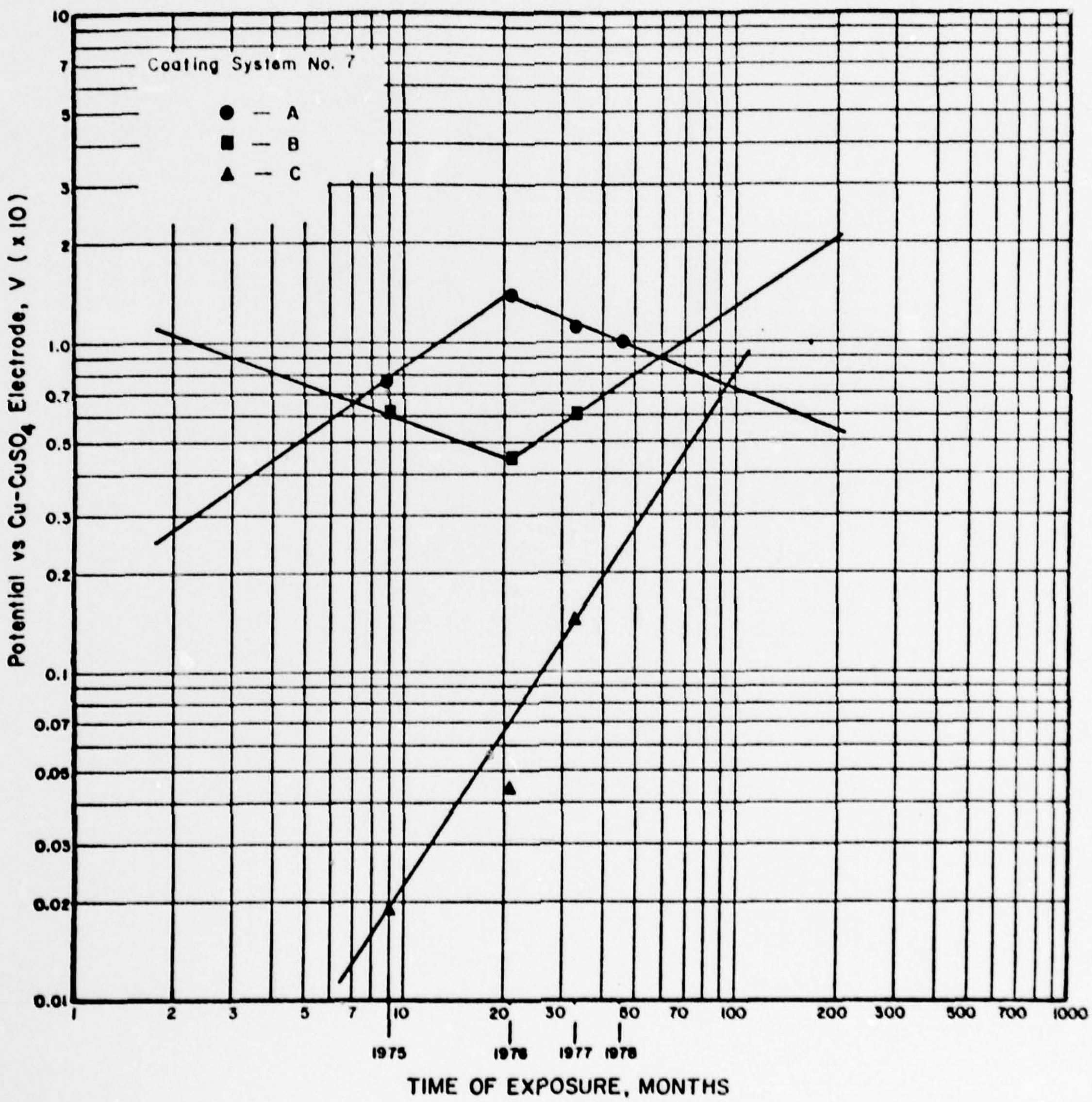
Pile No.	1975	1976	1977	1978
20A	6.36	4.64	9.33	5.2
B	7.39	2.91	2.0	4.17
C	0.23	0.542	1.6	2.89
21A	1.47	2.05	2.06	3.57
B	6.25	2.65	0.619	3.41
C	0.28	0.545	1.52	3.16
22A	–	0.378	1.40	3.19
B	–	0.375	0.076	2.95
C	Rows 22-24 Aux	Aux	1.49	Aux
23A	11.03	31.11	11.50	Connection Broken
B	4.22	8.26	3.13	
C	0.26	0.845	1.88	3.5
24A	22.50	50.0	Handles Broken	Connection Broken
B	4.29	4.77	2.50	Connection Broken
C	0.48	1.06	1.50	2.22
25A	–	–	–	
B	–	–	–	



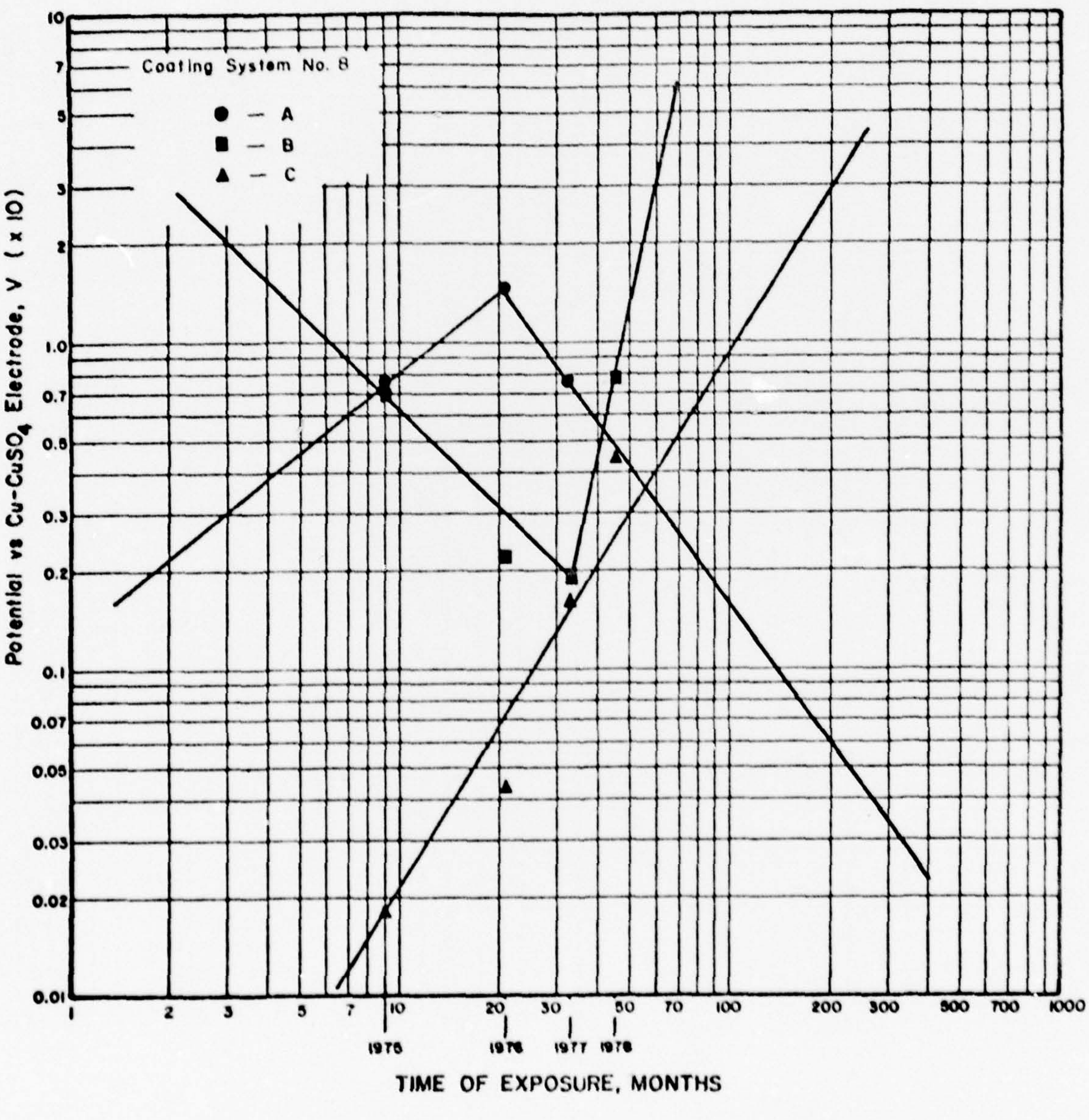
Coating System No. 1
● — A
■ — B
▲ — C
Potential vs Cu-CuSO$_4$ Electrode, V
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS

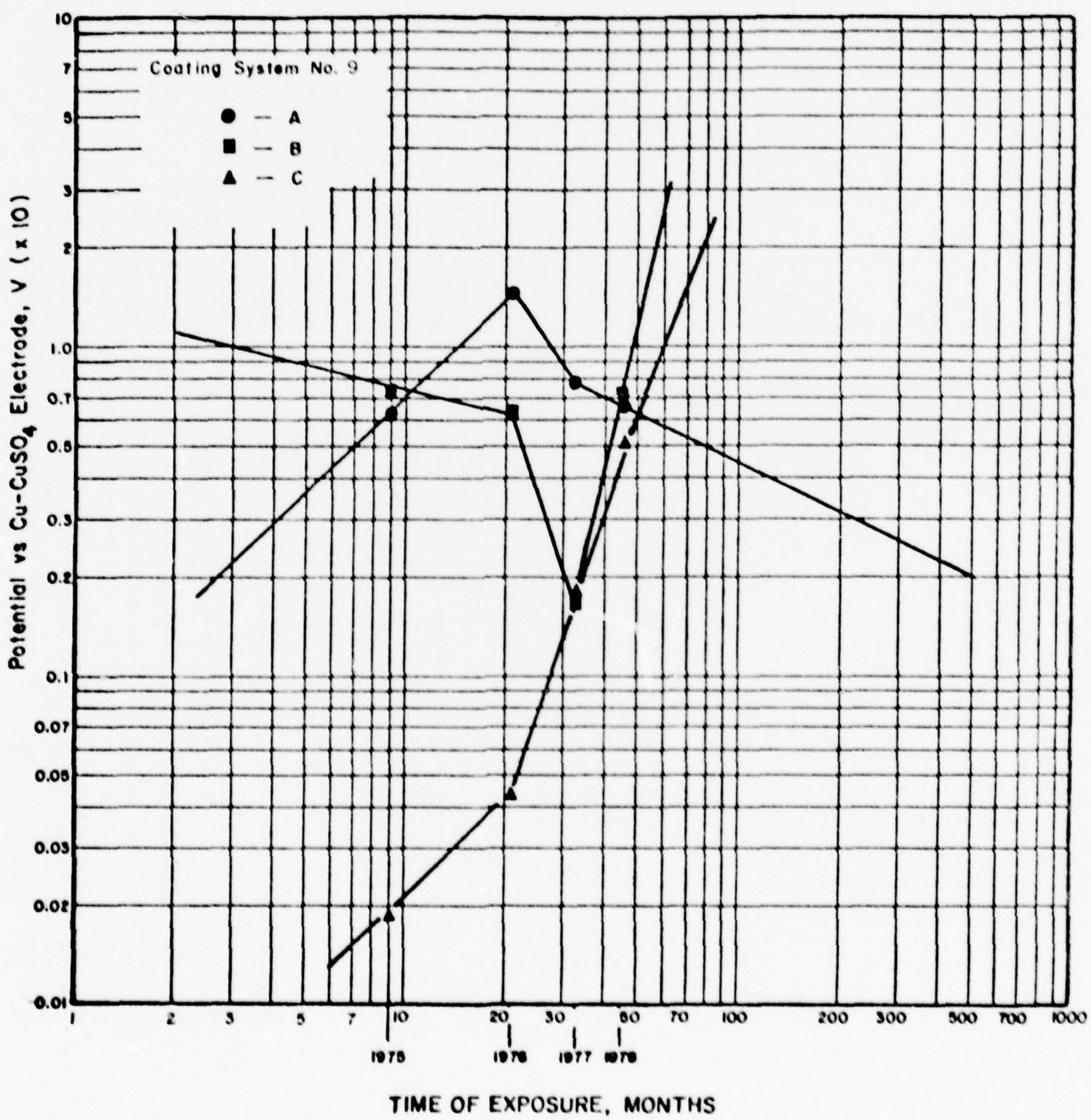


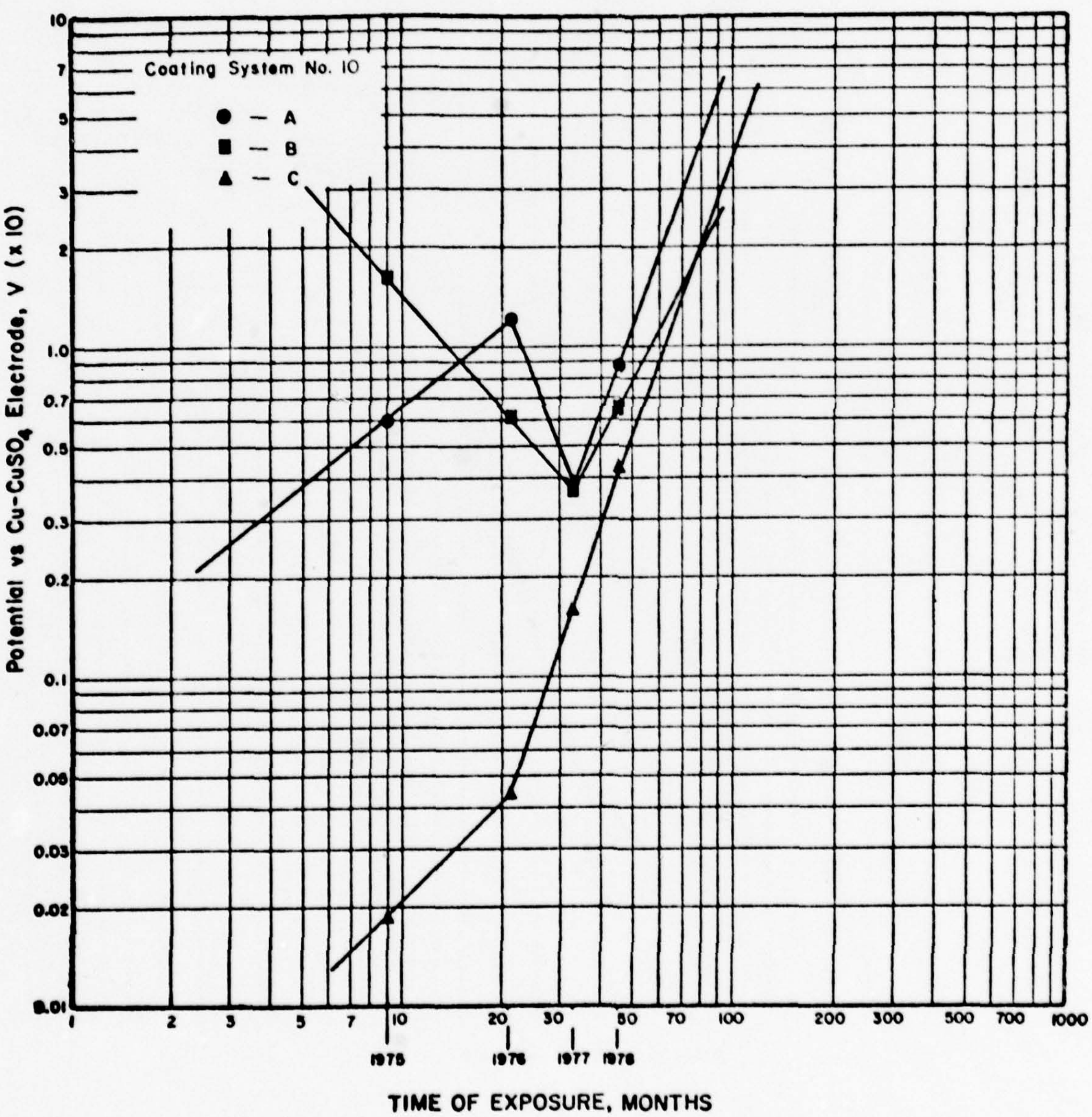
Coating System No. 4
● — A
■ — B
▲ — C
Potential vs Cu-CuSO4 Electrode, V
0.01
0.02
0.03
0.05
0.07
0.1
0.2
0.3
0.5
0.7
1.0
2
3
5
7
10
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS



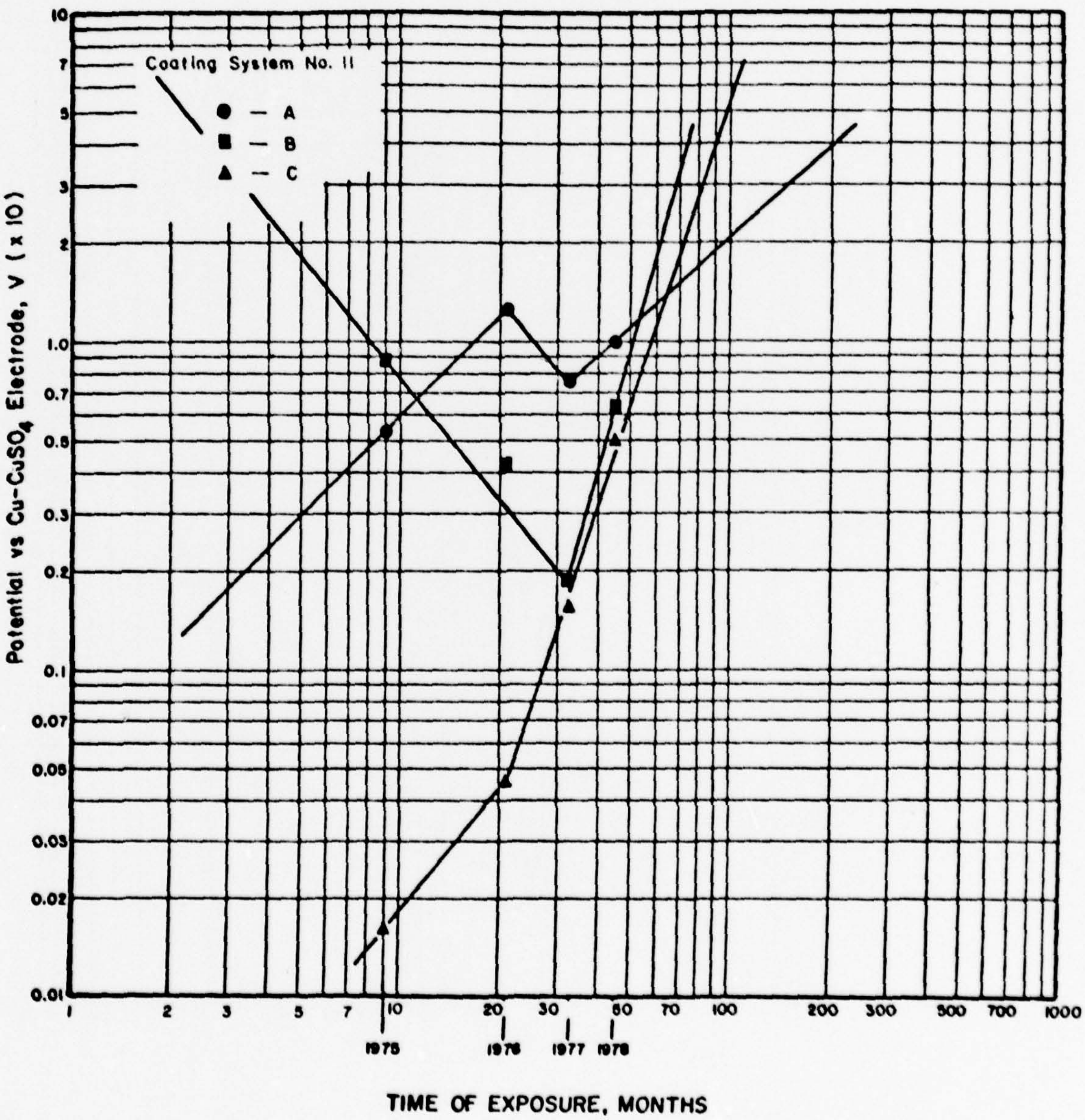
Coating System No. 7
● — A
■ — B
▲ — C
Potential vs Cu-CuSO4 Electrode, V (x10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS


Coating System No. 8
A
B
C
Potential vs Cu-CuSO4 Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS

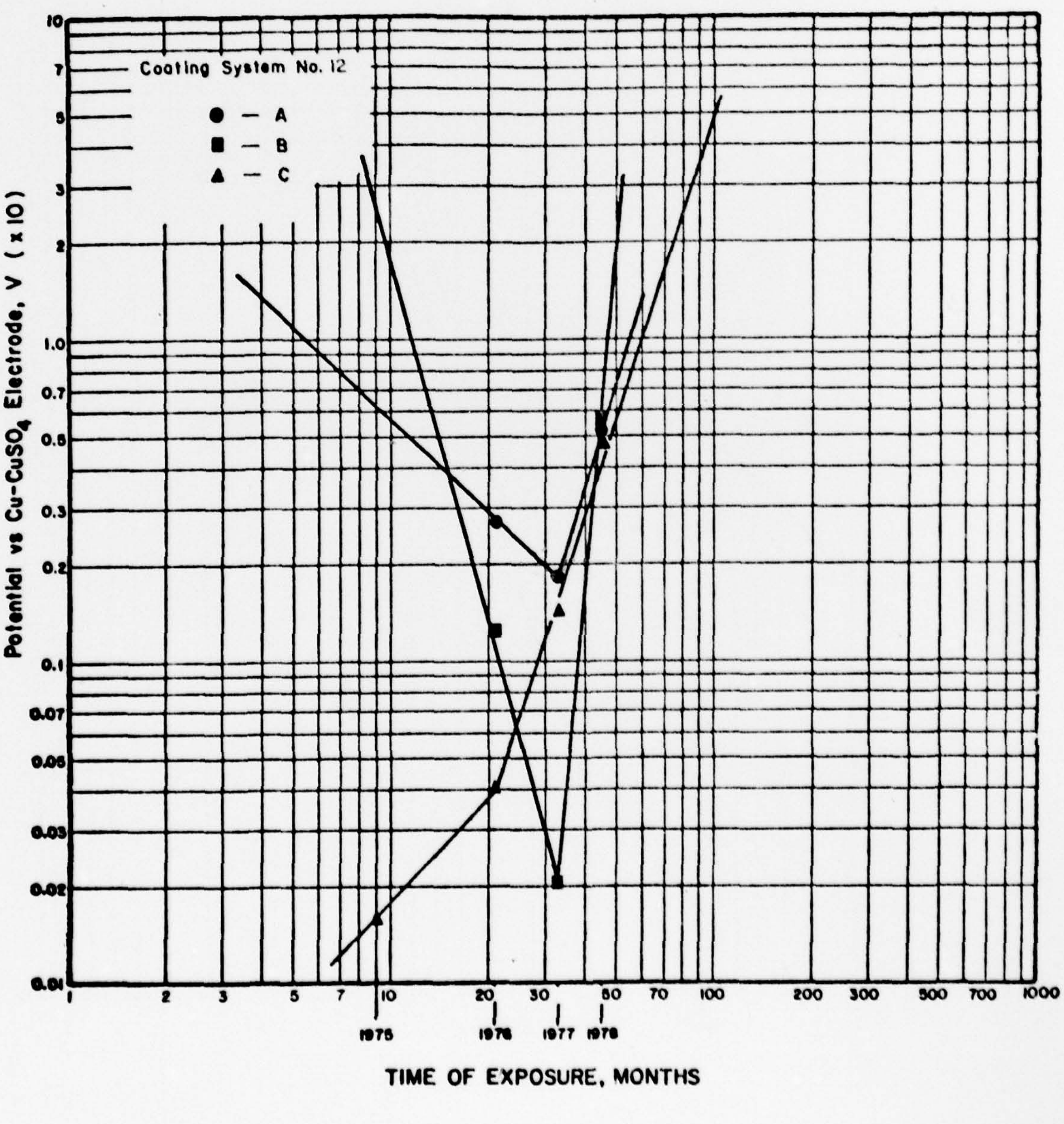

Coating System No. 9
● — A
■ — B
▲ — C
Potential vs Cu-CuSO4 Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS

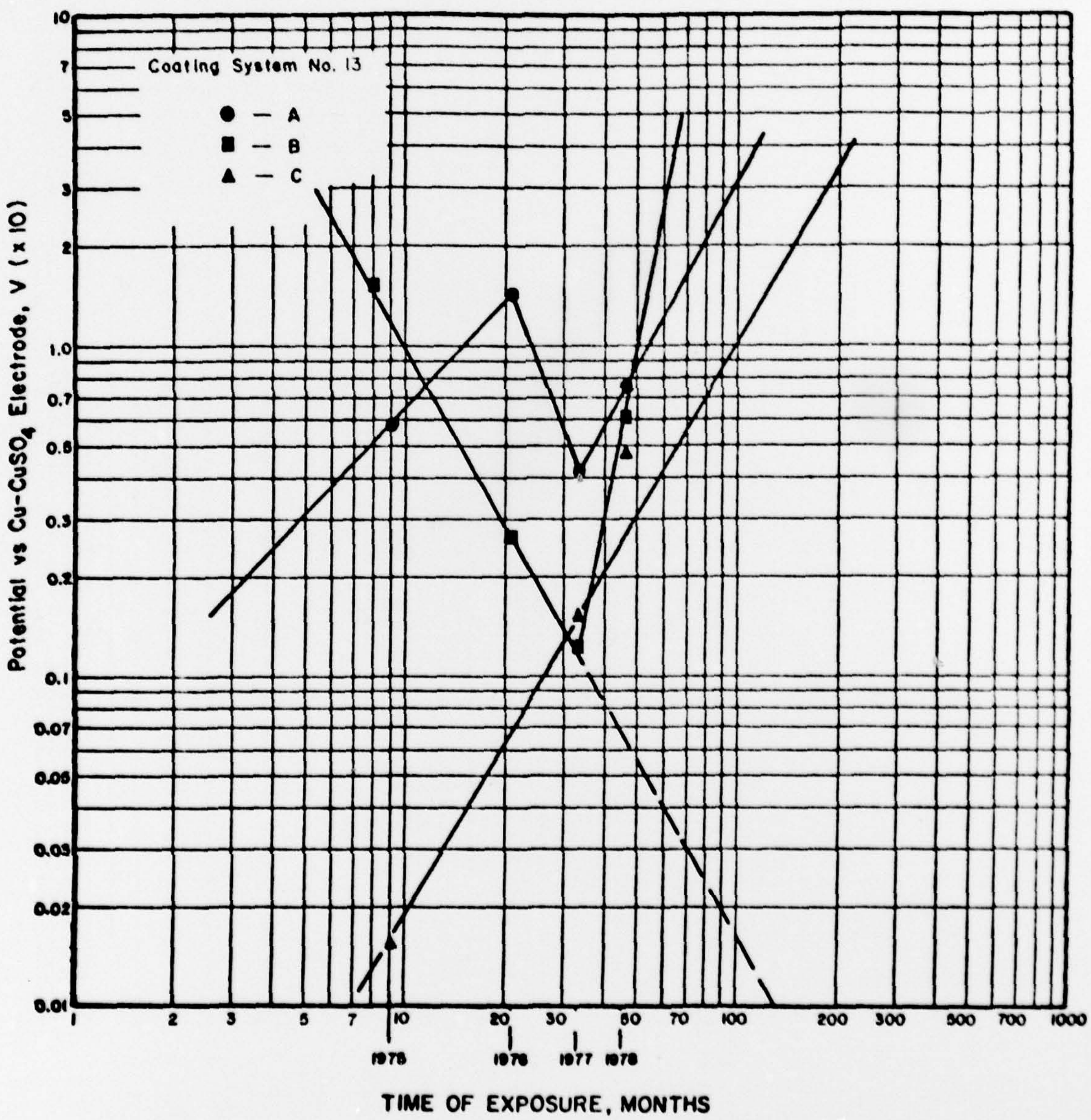


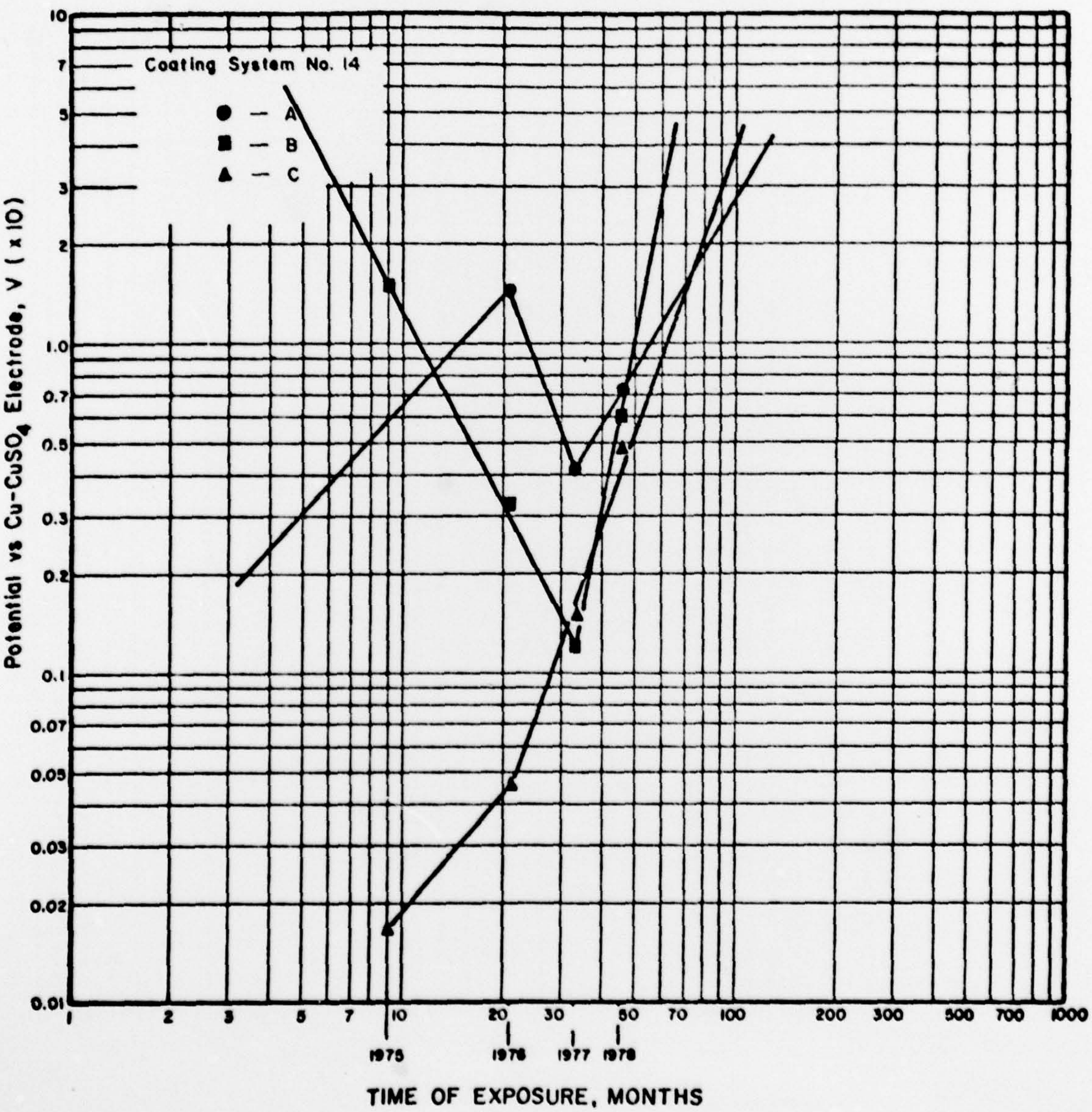
Coating System No. 10
● — A
■ — B
▲ — C
Potential vs Cu-CuSO4 Electrode, V (x 10)
TIME OF EXPOSURE, MONTHS
1975
1976
1977
1978

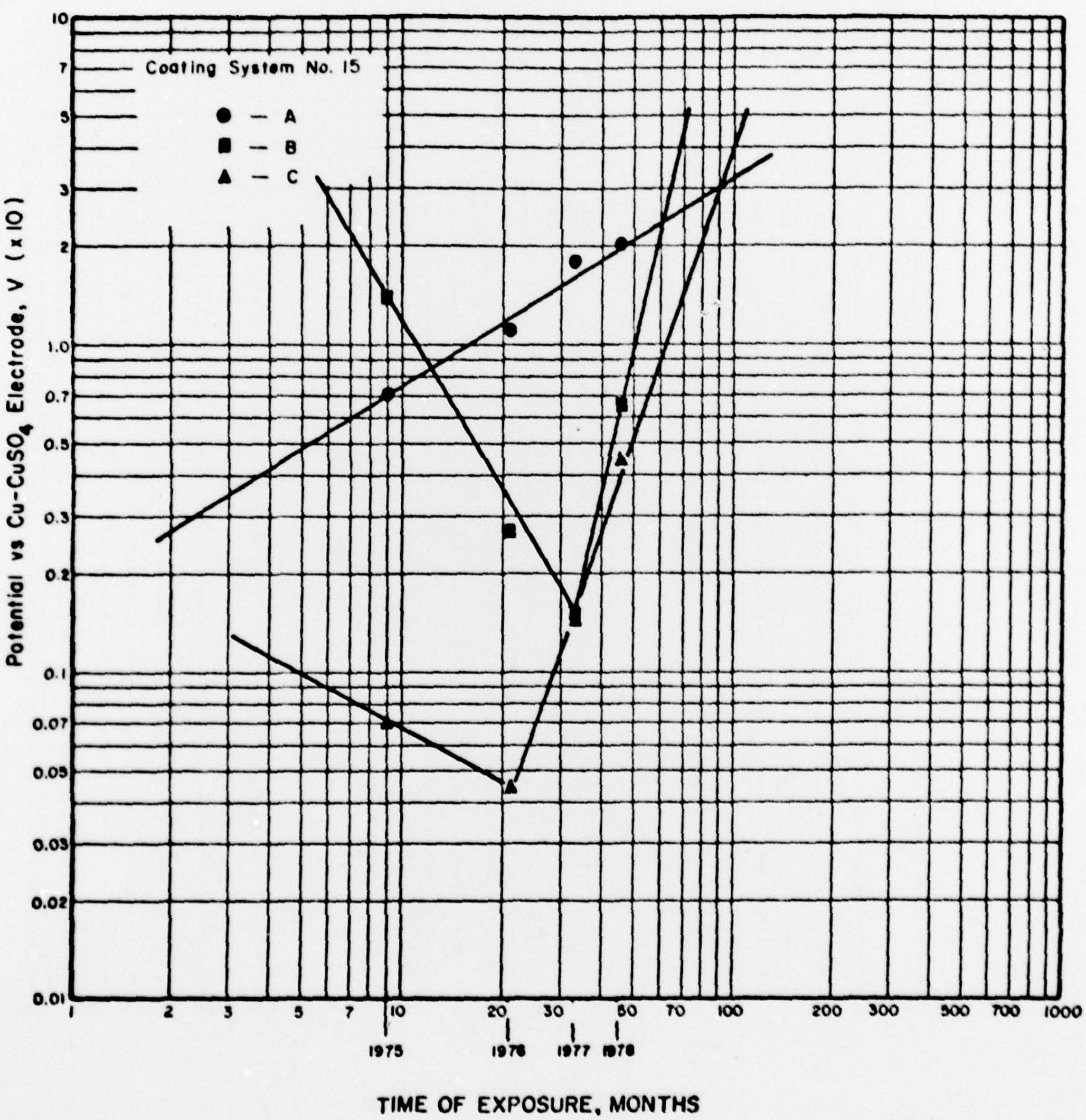


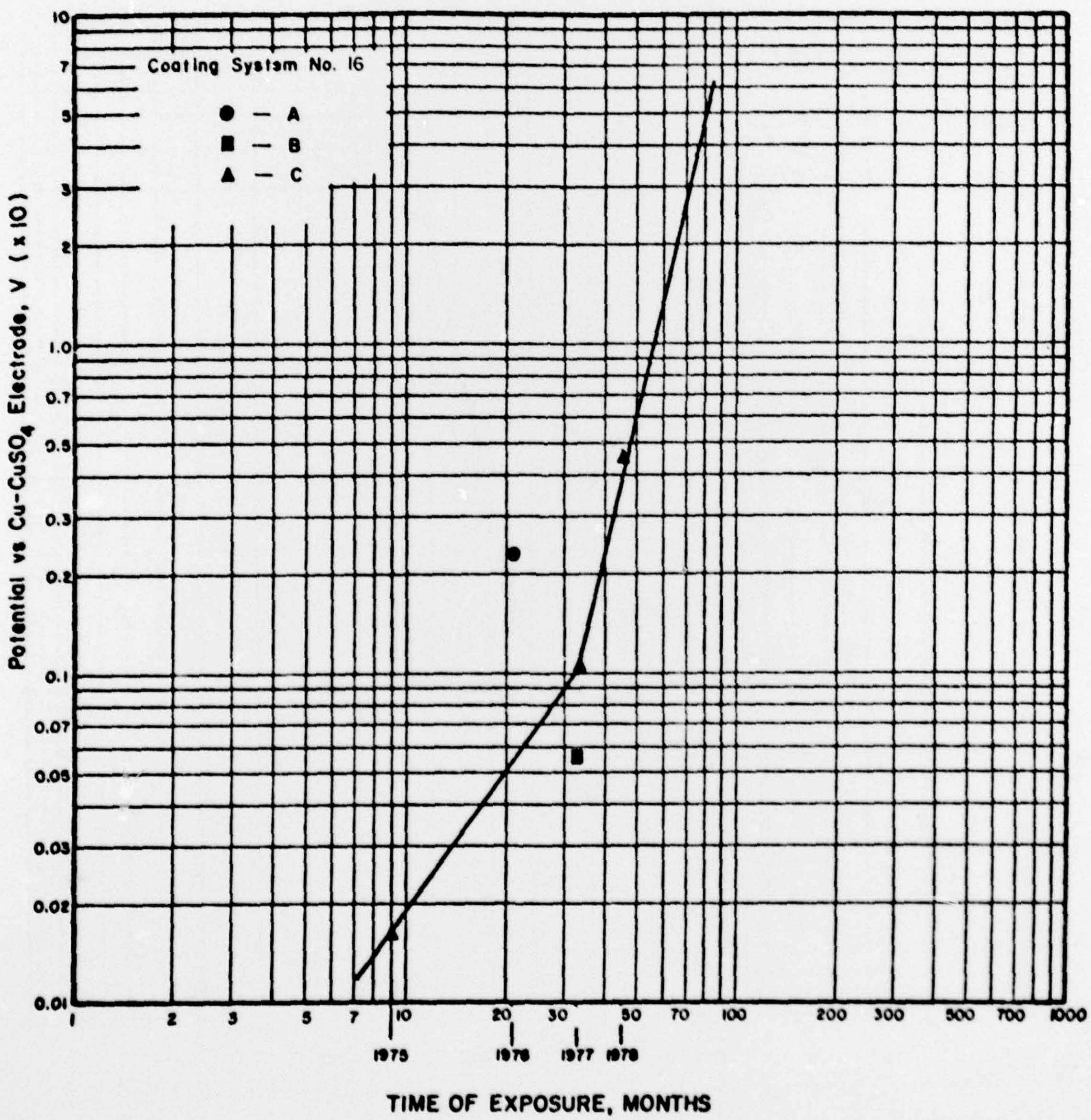
Coating System No. 11
● — A
■ — B
▲ — C
Potential vs Cu-CuSO4 Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS


Coating System No. 12
● — A
■ — B
▲ — C
Potential vs Cu-CuSO$_4$ Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS


Coating System No. 13
● — A
■ — B
▲ — C
Potential vs Cu-CuSO4 Electrode, V (x 10)
TIME OF EXPOSURE, MONTHS
1975
1976
1977
1978
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000


Coating System No. 14
● — A
■ — B
▲ — C
Potential vs Cu-CuSO4 Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS


Coating System No. 15
● — A
■ — B
▲ — C
Potential vs Cu-CuSO$_4$ Electrode, V (x 10)
TIME OF EXPOSURE, MONTHS
1975
1976
1977
1978



Coating System No. 16
● — A
■ — B
▲ — C
Potential vs Cu-CuSO4 Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
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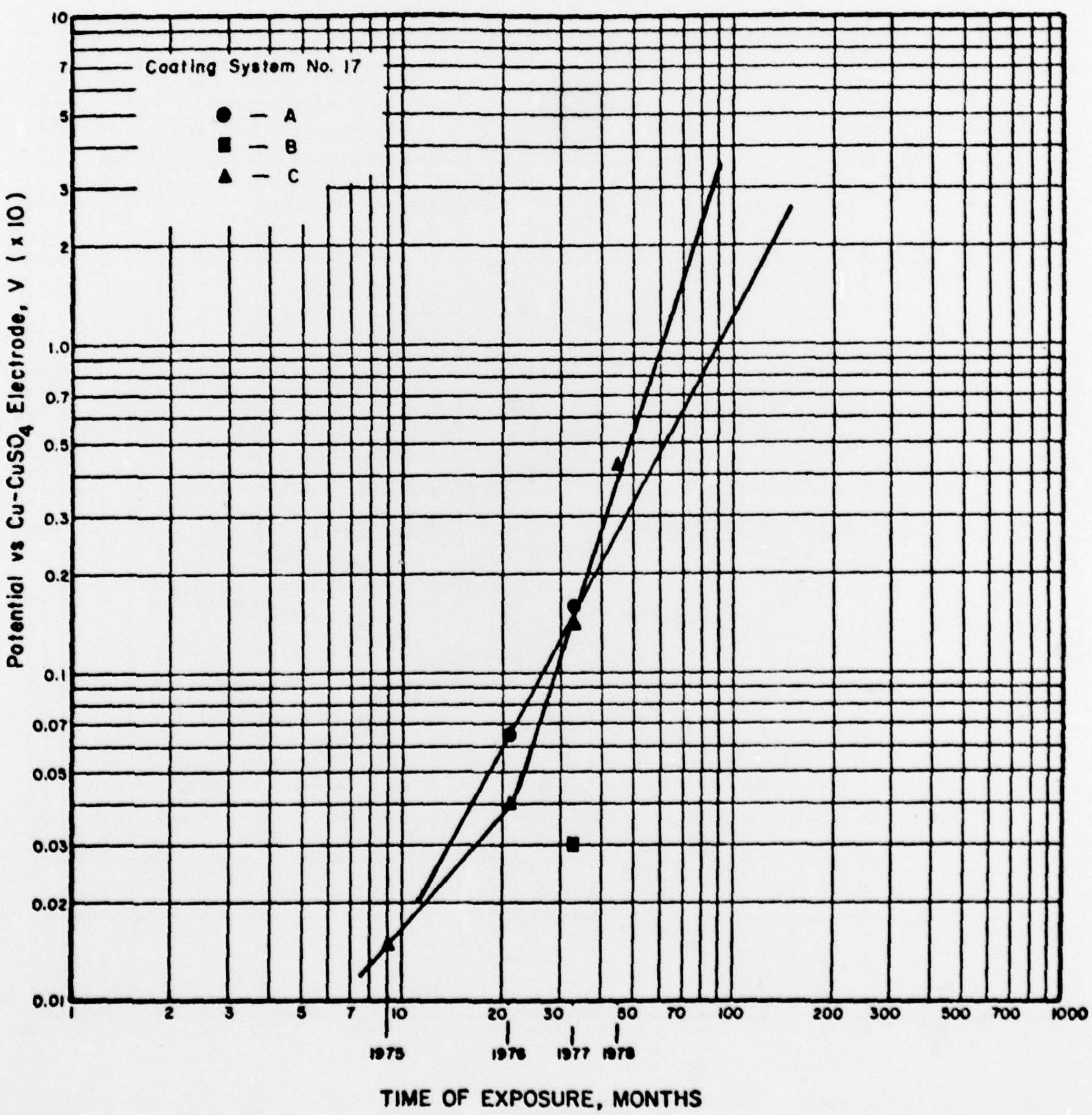
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS


Coating System No. 17
● — A
■ — B
▲ — C
Potential vs Cu-CuSO4 Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
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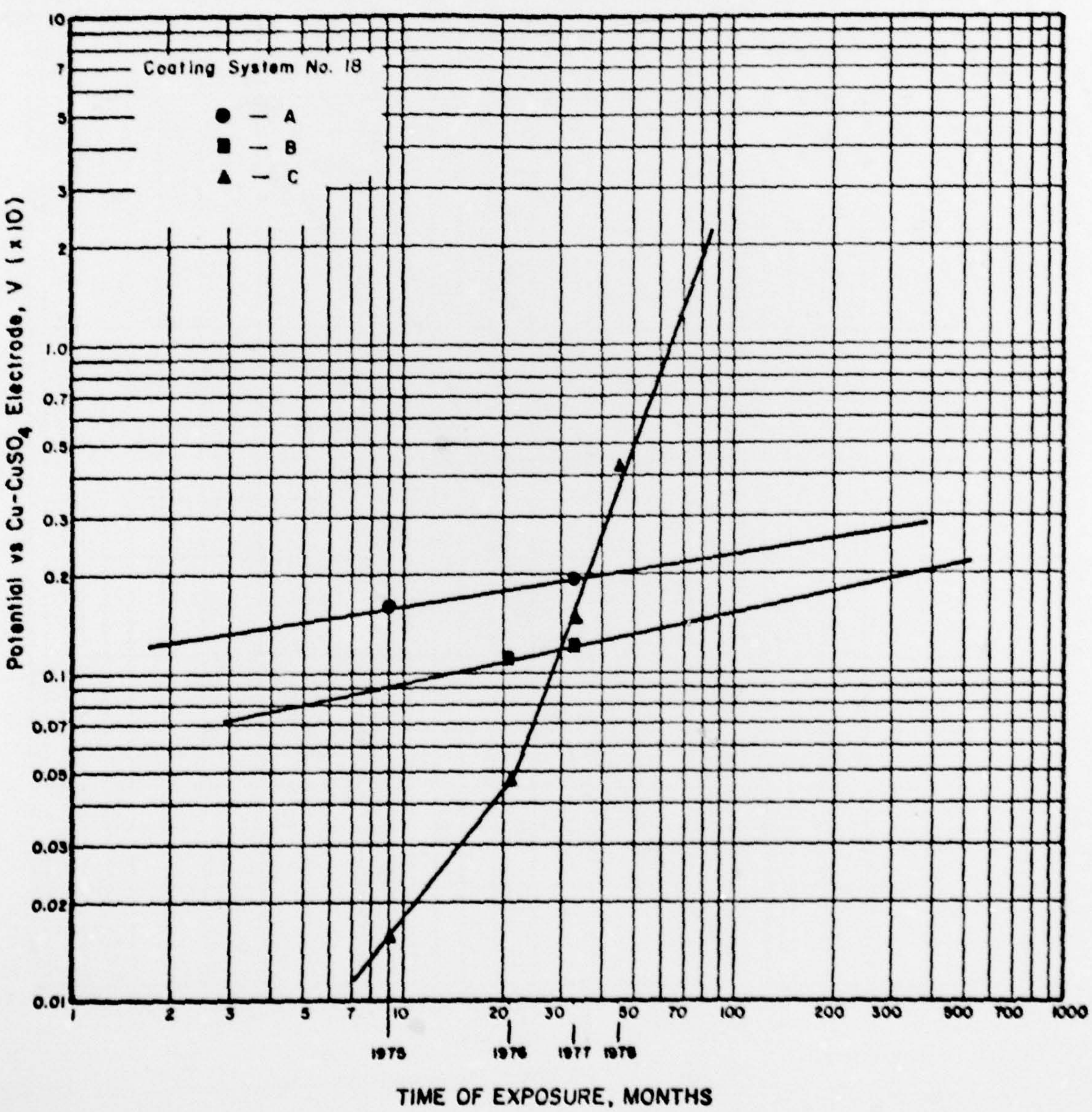
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS


Coating System No. 18
● — A
■ — B
▲ — C
Potential vs Cu-CuSO4 Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
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20
30
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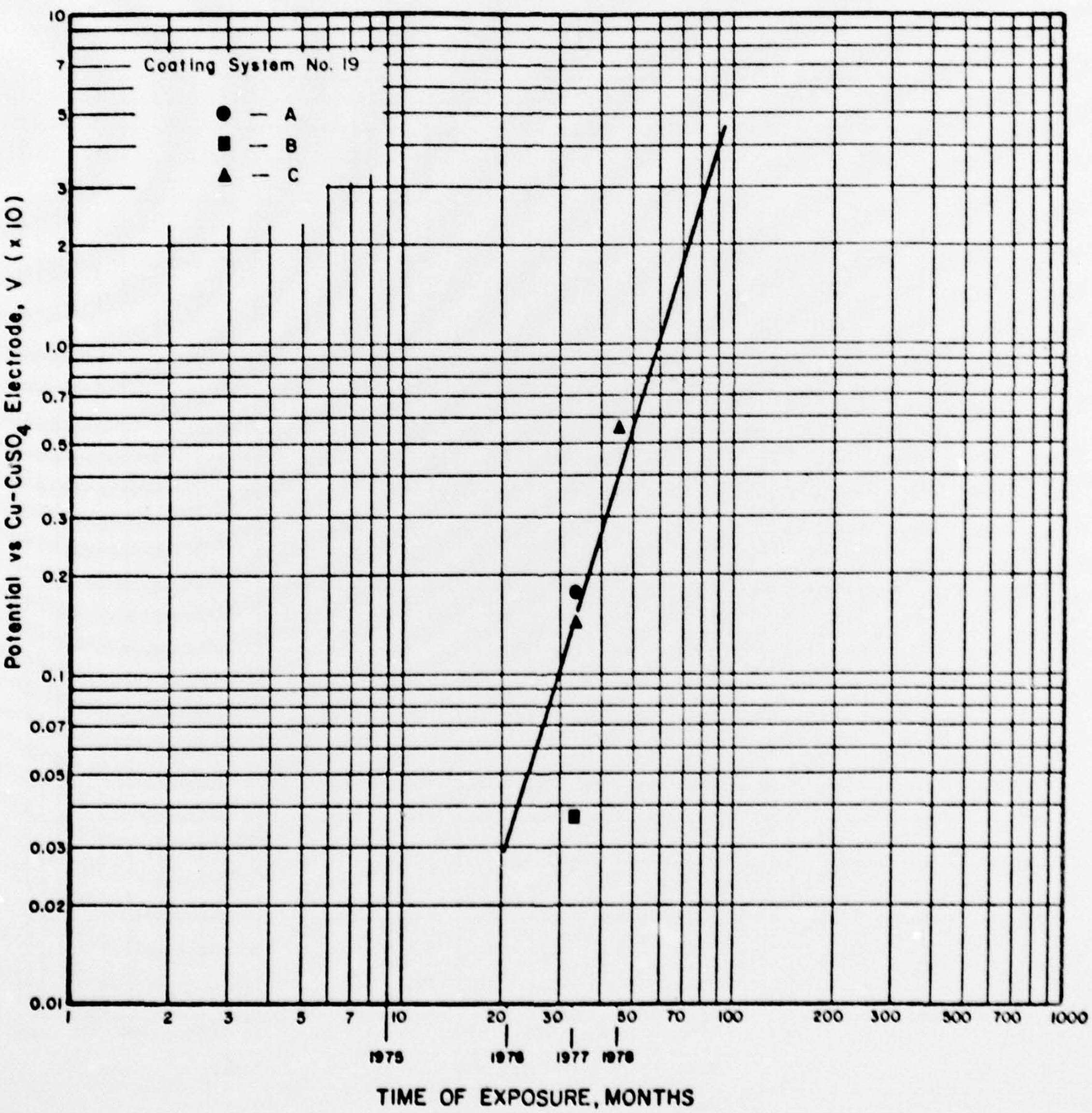
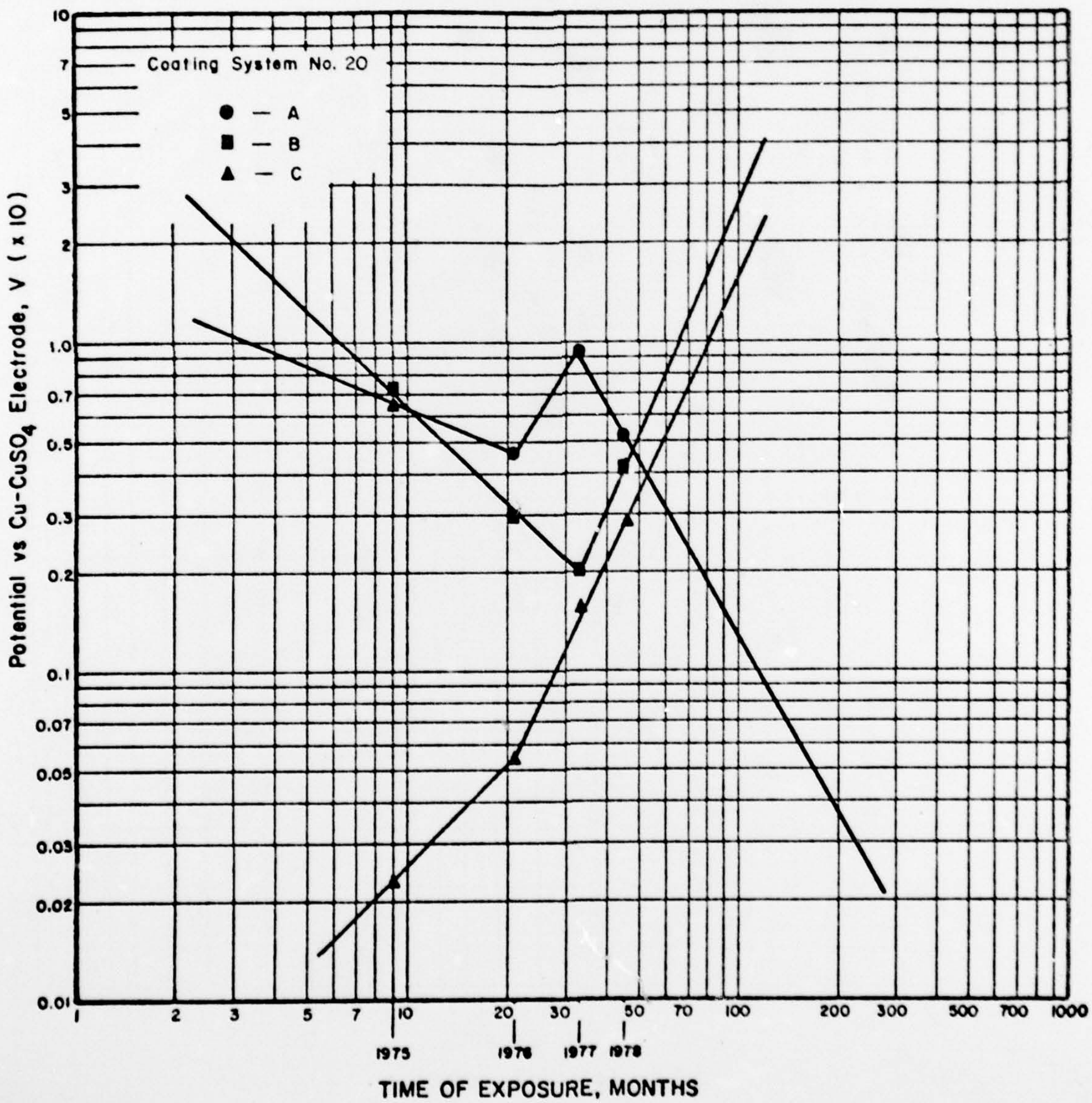
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS


Coating System No. 19
— A
— B
— C
Potential vs Cu-CuSO4 Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS


Coating System No. 20
● — A
■ — B
▲ — C
Potential vs Cu-CuSO$_4$ Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
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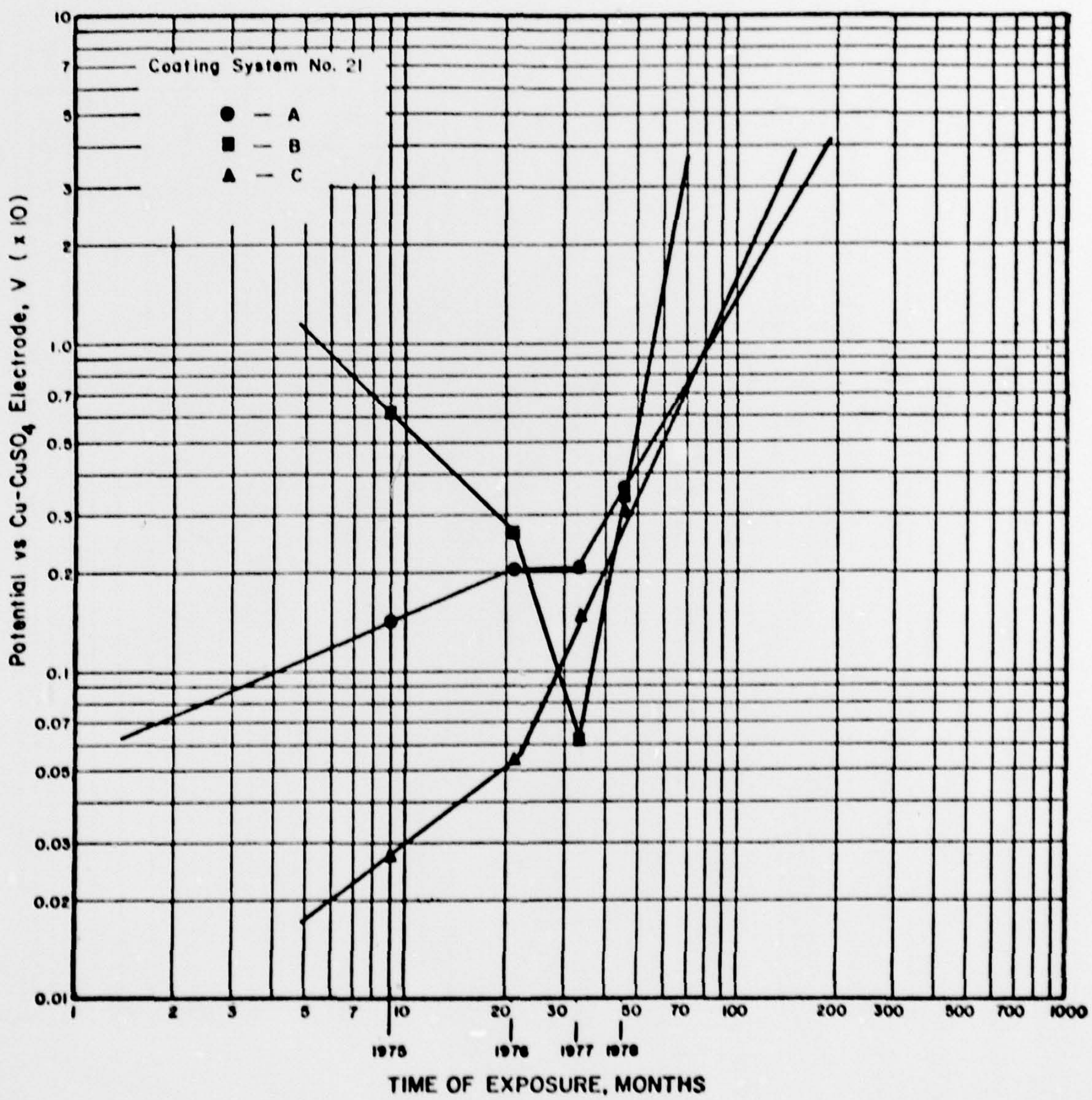
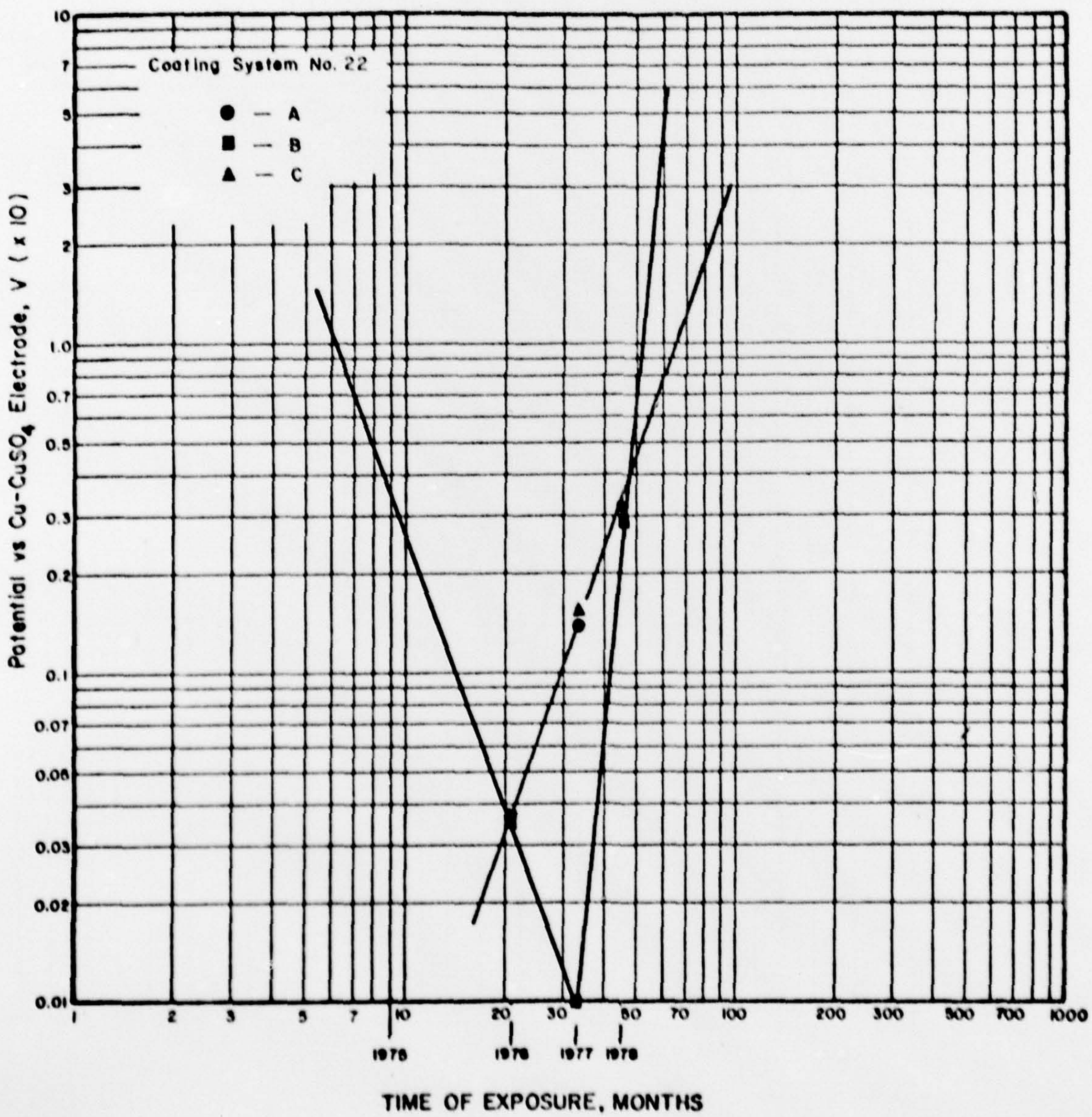
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS



Coating System No. 21
● — A
■ — B
▲ — C
Potential vs Cu-CuSO$_4$ Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS


Coating System No. 22
A
B
C
Potential vs Cu-CuSO4 Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
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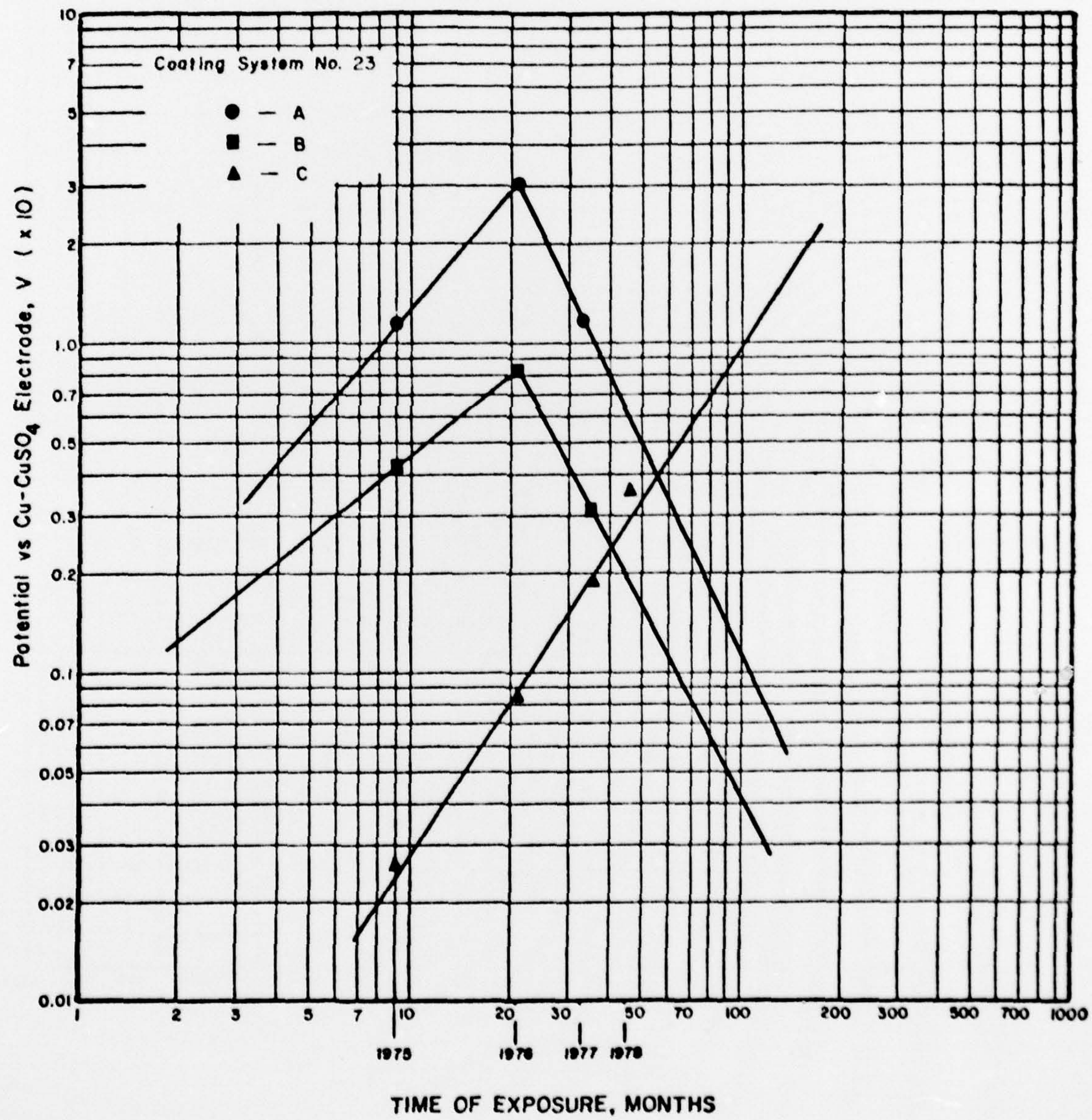
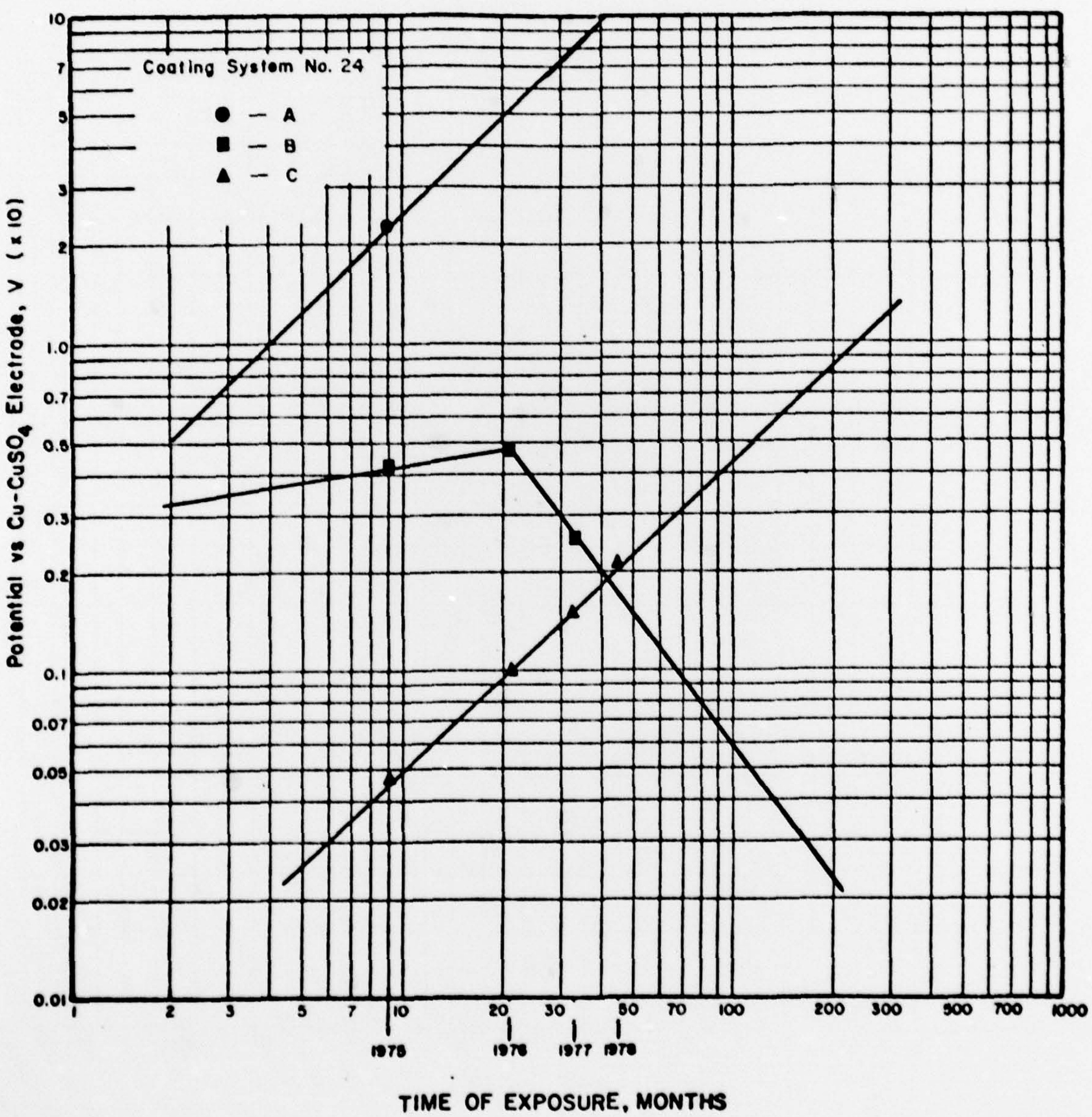
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS


Coating System No. 23
— A
— B
— C
Potential vs Cu-CuSO4 Electrode, V (x 10)
TIME OF EXPOSURE, MONTHS
1975
1976
1977
1978



Coating System No. 24
— A
— B
— C
Potential vs Cu-CuSO4 Electrode, V (x 10)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
0.07
0.05
0.03
0.02
0.01
1
2
3
5
7
10
20
30
50
70
100
200
300
500
700
1000
1975
1976
1977
1978
TIME OF EXPOSURE, MONTHS

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152 p. ; 27 cm. (Interim report ; M-275)

1. Seawater corrosion. 2. Buzzards Bay, MA. 3. Steel piling -- corrosion.
I. Title. II. Series: U.S. Army Construction Engineering Research Laboratory.
Interim report ; M-275.